FACTORS INFLUENCING AIR QUALITY HEALTH INDEX ADOPTION

FACTORS INFLUENCING AIR QUALITY HEALTH INDEX ADOPTION BY THE AT RISK POPULATION IN HAMILTON, CANADA

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy

McMaster University DOCTOR OF PHILSOPHY (2016) Hamilton, Ontario
(School of Geography and Earth Sciences)

TITLE: Factors Influencing Air Quality Health Index (AQHI) Adoption by the "At Risk" Population in the City of Hamilton, Ontario, Canada.

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NUMBER OF PAGES: xiv, 181

Abstract

The Air Quality Health Index (AQHI) is a 10-point scale that communicates the cumulative health risks associated with air pollution (ECCC, 2016). The general theme of this dissertation centers on an understanding of AQHI adoption while accounting for socioeconomic status (SES) in order to facilitate AQHI uptake by the public with particular focus on "at risk" populations (i.e. young children, seniors, and those with pre-existing respiratory and/or cardiovascular conditions). The study is unique since it approaches AQHI adoption consistent with the ecological model and an equity lens, and AQHI adoption is considered at the individual, organizational and community levels. The study area for this dissertation is Hamilton, Ontario, Canada. The findings from this dissertation contribute to an understanding of why AQHI is or is not being adopted and suggests potential intervention strategies to increase its uptake. Consistent with health behaviour theory, demographics (gender, age, education, area of residence), knowledge/understanding and individual risk perceptions (neighbourhood air effects on health) were found to be significant predictors of AQHI adoption. Additionally, perceived benefits of AQHI adoption included protection of health for self and those cared for via familial and/or occupational duties. While perceived barriers of AQHI adoption included lack of time required to check and follow AQHI health messages and the inability to "self-identify" as belonging to the "at risk" population. This dissertation proposes that increases in AQHI adoption may be achieved by increasing AQHI knowledge and emphasizing the benefits and relevance of AQHI such that "at risk" populations can self-

identify. Additionally, AQHI uptake may be increased by providing AQHI information at a neighbourhood scale via local media sources and wearable devices.

ACKNOWLEDGEMENTS

I would like to sincerely thank my thesis supervisor, Dr. K. Bruce Newbold, who provided me with valued feedback throughout the PhD program. I would also like to thank Dr. John Eyles and Dr. Allison Williams, who provided me with insightful guidance and comments throughout this thesis research process. I am particularly grateful for their time, patience and generosity in reviewing multiple drafts of the thesis papers. It has been a great privilege and a pleasure to work with each of them.

I would also like to thank my colleagues at the City of Hamilton Public Health Services for their support and encouragement throughout the process. Additionally, I would like to express my gratitude to colleagues at Health Canada and Environment Canada and Climate Change for their support during AQHI engagement and outreach in the City of Hamilton.

Finally, I would like to sincerely thank my family for inspiring me each and every day.

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Declaration of Academic Achievement

I am the primary author of the chapters included in this "sandwich" dissertation. Chapters three, four and five have been published and the pages have been renumbered for continuity purposes in this dissertation. This research was developed in consultation with my supervisor Dr. K. Bruce Newbold and my thesis committee. I collected and analyzed the data and authored all chapters. The contributions of co-authors for each chapter along with the year the research was conducted are provided below.

Chapter 1: Introduction

Sally Radisic – authored manuscript, and revised manuscript

Dr. Bruce Newbold – revised manuscript

Chapter 2: Methods

Sally Radisic – authored manuscript, and revised manuscript

Dr. Bruce Newbold – revised manuscript

Chapter 3: Factors influencing Health Behaviours in Response to the Air Quality Health Index: A Cross-Sectional Study in Hamilton, Canada

Radisic S, Newbold KB, Eyles J, Williams A. (2016). Factors Influencing Health Behaviours in Response to the Air Quality Health Index: A Cross-Sectional Study in Hamilton, Canada. *Environmental Health Review*, 59(1): 17-29.

Sally Radisic – design and conceptualization, data collection and analysis, authored manuscript, and revised manuscript

Dr. Bruce Newbold – design and conceptualization, and revised manuscript

Dr. John Eyles – design and conceptualization, and revised manuscript

Dr. Allison Williams – design and conceptualization, and revised manuscript

Research conducted 2012

Chapter 4: Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): a qualitative study

Radisic S and Newbold KB. (2016). Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): a qualitative study. *BMC Health Services Research,* 16(107). DOI: 10.1186/s12913-016-1355-0

Sally Radisic – design and conceptualization, data collection and analysis, authored manuscript, and revised manuscript

Dr. Bruce Newbold – design and conceptualization, and revised manuscript

Research conducted 2012-2015

Chapter 5: Air Quality and Health Education to Increase Knowledge and Encourage Health Protective Behavior Among Older Adults in Hamilton, Canada

Radisic S & Newbold KB. (2015). Air Quality and Health Education to Increase Knowledge and Encourage Health Protective Behavior Among Older Adults in Hamilton, Canada. *Environmental Health Review,* 58(4): 87-94.

Sally Radisic – design and conceptualization, data collection and analysis, authored manuscript, and revised manuscript

Dr. Bruce Newbold – design and conceptualization, and revised manuscript

Research conducted 2014

Chapter 6:

Sally Radisic – authored manuscript, and revised manuscript

Dr. Bruce Newbold – revised manuscript

Chapter 1: Introduction

1.1 Dissertation Theme

The general theme of this dissertation centers on an understanding of Air Quality Health Index (AQHI) adoption while accounting for socioeconomic status (SES) in order to facilitate AQHI uptake by the public with particular focus on "at risk" populations as defined by Environment Canada and Climate Change (ECCC, 2016) to be young children, seniors (≥ 65 years), and those with pre-existing respiratory and/or cardiovascular conditions. Therefore, to ensure consistency in terminology this dissertations embraces the same definition of "at risk" populations. AQHI adoption by the "at risk" population is critical with respect to decreasing adverse health effect from air pollution exposure and at the same time alleviating burden and costs to the health care system.

1.2 Air Pollution and Health

A large body of evidence has found air pollution exposure to be associated with adverse health effects (Anderson, 2010). For example, short-term epidemiologic studies have found a number of health effects due to air pollution exposure such as higher rates of myocardial infarction in individuals with risk factors for cardiovascular disease (Simkhovich et al., 2008); exacerbation of heart failures (Goldberg et al., 2008); higher incidence rates of cardiac arrhythmia (Simkhovich et al., 2008); exacerbation of obstructive respiratory illness like asthma and chronic obstructive pulmonary disease

(COPD) (Sunyer, 2001); increased respiratory inflammation and irritation (McCreanor et al., 2007); and diminished lung function (Brunekreef et al., 1995).

According to the World Health Organization (WHO), air pollution attributed deaths were estimated to have reached 3.7 million world-wide in 2012 (WHO, 2014). The Canadian Medical Association (CMA) estimated that in 2008, approximately 21 000 deaths, 11 000 hospital admissions, and 92 000 emergency visits were associated with air pollution in Canada. Additionally, research has found that some people are more sensitive to air pollution including young children (WHO, 2015), seniors (Bentayeb, 2012) and those with pre-existing respiratory and/or cardiovascular conditions (WHO, 2015).

Therefore, strategies to protect public health from air pollution exposure are critical to population health protection. Accordingly, in Canada, the Air Quality Health Index (AQHI) was developed by federal, provincial and municipal governments to help protect the public from adverse health effects of air pollution exposure (Environment Canada and Climate Change (ECCC), 2016). This health protection tool relies on the public's adoption of health protective behaviours (i.e. reduce/reschedule outdoor activity) to decease air pollution exposure and adverse health effects.

1.3 Defining the AQHI

The AQHI is a comparatively easy to understand 10-point scale (low risk 1-3, medium risk 4-6, high risk 7-10, very high risk greater than 10); as presented in Figure 1

(Environment Canada Climate Change (ECCC), 2016). Unlike the older Air Quality Index (AQI) which was based on six pollutants (ozone (O_3), fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total reduced sulphur (TRS)) and communicated the single worst pollutant, the AQHI communicates the cumulative health risks for the pollutants in the index (O_3, NO_2, $PM_{2.5}$) known to be hazardous to human health (ECCC, 2016).

Figure 1. Air Quality Health Index (AQHI) Scale

Hence, the AQHI is considered best suited to communicate health risks associated with air pollution (ECCC, 2016). The AQHI provides health messages for each category of health risk advising the public to implement health protective behaviour for both the "at risk" (young children, elderly and those with pre-existing respiratory and/or cardiovascular conditions) and general populations which are provided in Table1.

Initially, AQHI was reported as a pilot in various municipalities across Canada including Hamilton starting in 2011. As of June 2015, the AQHI was reported provide-

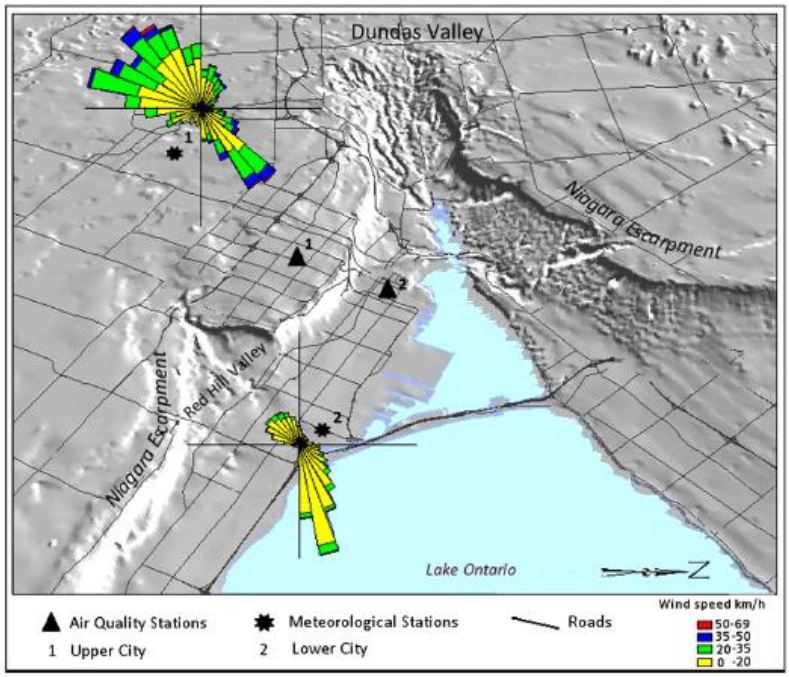
wide in Ontario, replacing the AQI (Ministry of Environment and Climate Change (MOECC), 2010). Subsequently, adoption of the AQHI by the population, particularly those "at risk" populations has the potential to protect health from air pollution exposure and decrease burden on the health care system which has been estimated to have reached $8 billion in 2008 and expected to surpass $250 billion by 2031 in Canada (CMA, 2008).

1.4 Air Quality in Hamilton

Our study area includes Hamilton, Ontario, Canada, an industrial city that lies to the west of Toronto. Given its industrial heritage, a significant amount of research associated with air quality and health outcomes has been conducted, with work dating back to the 1970s (Barakat-Haddad et al. 2013).

In Hamilton, research has found spatial variability of air pollution concentrations (Buzzelli et al. 2003; Jerrett et al. 2001; Wallace et al. 2010). Similar findings at the neighbourhood level have been identified in other cities (Briggs et al., 2000; Jerrett et al., 2005). This spatial variability in Hamilton is influenced by a number of different factors including vehicles/traffic, industry/facilities, meteorological conditions/atmospheric inversions, and the geographical upper and lower city divide by the Niagara Escarpment, potentially entrapping pollutants in the lower and more easterly portions of the city (Wallace et al., 2010). Figure 2 illustrates some of these factors influencing spatial variability with wind rose diagrams for inversion days in Hamilton at the fixed air monitoring stations with the Niagara Escarpment divide (Wallace et al., 2010).

Figure 2. Wind rose diagrams for inversion days according to wind speed in Hamilton with Niagara Escarpment divide (Source: Wallace et al., 2010)



1.5 Health Disparities

Research has shown that exposure to air pollution is not evenly distributed and that those in lower socioeconomic status (SES) areas are often exposed to greater concentrations of air pollutants than those in higher SES areas (Brulle and Pellow, 2006; Hajat et al., 2013;Jerrett et al., 2004; Jerrett et al., 2005a; Jerrett et al., 2005b; Jerrett et al., 2008). Likewise, research has established that those of lower SES have poorer health than those of higher SES (Marmot et al., 2006).

In 2010, the local newspaper, the *Hamilton Spectator* reported a special investigative series entitled: "CODE RED" to describe the disparities in health and health status found in the city (Buist, 2010). Findings showed that lower SES areas of Hamilton have the

highest total emergency department visit rates, highest respiratory-related emergency room visit rates, and high cardiovascular-related emergency room visit rates per 1000 people (Buist, 2010); this group comprises the "at risk" population for the AQHI. Therefore, this data suggests that the lower SES area of the City of Hamilton would benefit considerably from the adoption of the AQHI.

Echoing the broader literature, age, income and neighbourhood are key determinants of health for residents in Hamilton neighborhoods (Wilson et al., 2009).

1.6 Perceptions of Air Quality and Health

Well over a decade ago, residents in the lower SES neighbourhood within close proximity to industry in Hamilton reported that they were concerned about the effects of air pollution upon their health and the health of those who lived with them (Elliott et al., 1999). Therefore, the effects of air pollution on health have been recognized as a concern by residents in the low SES neighbourhood of the city for an extended period of time. Some years later, residents in lower SES neighbourhoods who reported discontent with their neighbourhood physical environment were 1.5 times more likely to report chronic health conditions (Wilson et al., 2004).

Local perceptions of the environment and air quality are also linked to health outcomes. Residents in the lower SES neighbourhoods were, for example, more likely to report air pollution as a health hazard than those in the higher SES neighbourhood (Eyles et al., 2009). Furthermore, residents from the lower SES neighbourhood were more likely

to report air pollution from industry as a health concern than residents in higher SES neighbourhoods. Thus, results indicate that perceptions of the environment and its perceived relation to health vary with SES. Similarly, research examining the factors that influence lay perceptions of air quality in the City of Hamilton found that residents in the higher SES neighbourhood were 6 times more likely to report a "good" perception of air quality than those living in the lower SES neighbourhood (Simone et al., 2012). In addition, socio-demographic factors were found to be significant in influencing air quality perceptions in the lower SES neighbourhood. Therefore, this research supports the idea that individuals in higher SES are less likely to report their environment as being hazardous than those of lower SES.

Data collected in the City of Hamilton in 2009 focused on resident's perception of outdoor air quality and its impacts on health and its relationship to behaviour change. Findings indicated that approximately 75% of residents perceived that the outdoor air quality had negative effects on the health of Hamilton residents but only 22% reported that they changed their behaviour because of poor air quality (City of Hamilton Applied Research and Evaluation Team, 2009). Therefore, this information would suggest that perceptions of air quality alone may have limited impact on changing behaviour in the population.

1.7 Dissertation Organization

Each of the chapters in this dissertation contributes to the general knowledge about understanding AQHI adoption in Hamilton. We conclude this introduction with a brief description of the chapters to follow.

In chapter 2 we describe health behaviour theory used, the conceptual framework developed, along with the mixed methods employed and provide an overview of the research in its entirety. The overview illustrates how each phase of the research is informed by the one before it with the first phase setting the foundation.

Chapter 3 uses binary logistic regression to predict the probability of AQHI adoption. The quantitative method allows us to understand which factors influence AQHI adoption in the population. The objective in this chapter was not only to understand what factors influence AQHI adoption but also to identify potential intervention strategies to increase AQHI uptake via open-ended survey questions. In this chapter, results illustrate that demographics (gender, age, education, area of residence), knowledge/understanding and individual risk perceptions (neighbourhood air effects on health) were significant predictors of AQHI adoption. Moreover, results suggest that the perceived benefits of AQHI adoption included protection of health for self and those cared for via familial and/or occupational duties; while perceived barriers of AQHI adoption included lack of knowledge about where to check and lack of time required checking and following AQHI health messages. Also, in this chapter, we uncover self-efficacy as a factor influencing AQHI adoption. Chapter 3 provides the groundwork for all other chapters that follow in this dissertation.

Chapter 4 focuses on "at risk" populations and explores AQHI adoption by health care and service providers and the "at risk" populations they care for. Qualitative methods, including interviews and focus groups, are used to uncover themes related to AQHI knowledge, factors influencing AQHI adoption and strategies to increase AQHI

uptake. Findings illustrate that AQHI knowledge, AQHI characteristics and perceptions of air quality and health influenced AQHI adoption. Moreover, the findings suggest that AQHI knowledge centred on numerical reliance and health protective intent but varied with SES. We uncover that more emphasis on AQHI relevance with respect to health benefits is required to stress relative advantage over other indices and reduce index confusion. In this chapter, we also find that AQHI reporting at a neighborhood scale was recognized as addressing geographic variability and uncertainty in perceived versus measured air quality impacting health. Additionally, this chapter points out that participants predominantly expressed that they relied on sensory cues (i.e. feel, see, taste) to determine when to implement health protective behaviors. As in the previous chapter, the Chapter 4 findings once again uncover time constraints as barriers to AQHI adoption. However, in Chapter 4 local media reporting and wearable devices were identified as facilitators to AQHI adoption.

In Chapter 5, we implement an intervention strategy informed by the preceding studies. We focus on older adults (≥65 years) and conduct an education session to increase AQHI awareness and encourage AQHI adoption. We use this intervention to evaluate its effectiveness in this "at risk" population. In this chapter, results indicated a statistically significant difference in pre- and post-test knowledge (p<0.05). Furthermore, our findings show that after the education session, 82% of participants indicated intention to use AQHI. Similar to our findings in previous chapters of this dissertation, in Chapter 5, we find that the benefit of AQHI adoption included health protection while the most relevant barrier was the inability to self-identify as belonging to the "at risk" population.

Our findings in Chapter 5 suggest that the AQHI education session was an effective intervention to increase AQHI knowledge and encourage use of the AQHI.

Finally, in Chapter 6 we summarize the findings, present our contributions and discuss the limitations to our work along with recommendations for future work.

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Chapter 2: Methods

This dissertation incorporates health behaviour theory and embraces the ecological perspective. Accordingly, the conceptual framework used to investigate the factors influencing AQHI adoption by the "at risk" population in the City of Hamilton is presented in Figure 1. The conceptual framework illustrates the three levels of influence outlined by the ecological perspective which are involved in AQHI adoption and include: individual, organizational, and community. The conceptual framework also indicates that the health behaviour theories employed include the Health Belief Model (Hochbaum, 1958; Rosenstock, 1974) and the Diffusion of Innovations Model (Rogers, 2003). In this framework, theory, research and practice come together to explain AQHI adoption in the City of Hamilton.

2.1 Health Behaviour Theory

Health behaviour theories are effective tools that can be used to explain behaviour and offer insight with respect to interventions that can change behaviour (Glanz et al., 2008). Hence they are effective tools for this dissertation given that the general theme involves an understanding of why people do or do not engage in the health protective behaviour associated with AQHI adoption such that greater uptake of the health protection tool can be fostered.

Furthermore, risk perceptions are found to be at the heart of most health behaviour theories; Brewer et al., (2007) in their meta-analysis of the relationship between risk perception and health behaviour found that risk perceptions are accurately positioned at

the center of health behaviour theories. Risk perceptions involve people's beliefs, attitudes, judgments, feelings and the cultural and social character they adopt with respect to hazards (Bickerstaff, 2004).

Glanz et al. (2008) points out that the use of one theory alone will most likely be inadequate in terms of addressing the majority of health behaviour issues. It is recommended that theories from more than one level of influence (i.e, individual, organizational, community) be integrated since strong influences take place at each of these levels. This approach is consistent with the ecological perspective.

The four fundamental beliefs of the ecological model include: (1) multiple levels of influence (individual, interpersonal, organizational, community, and public policy); (2) interaction of influences on behaviours across the multiple levels; (3) behaviour specificity with identification of most important influences at each level; and (4) multi-level interventions for successful behaviour change (Glanz et al., 2008). Ecological models provide guidance with respect to intervention strategies that can be applied at different levels of influence. Therefore, the ecological model asserts that behaviour change is most successful when it takes place in an environment with policies that support healthy behaviour, when social supports are in place to encourage the healthy behaviour and individuals have the awareness and knowledge to engage in the healthy behaviour (Glanz et al., 2008).

2.2 Mixed Methods Design

In Figure 1, it is apparent that the research employed mixed methods. By incorporating both quantitative and qualitative methodologies in this research study, factors influencing AQHI adoption by the "at risk" population were identified while also allowing for an in-depth understanding of those factors at the same time. Creswell (2009) indicates that timing, weight, and mixing are key factors that form a mixed methods approach.

The mixed methods design consisted of an explanatory sequential design (Creswell, 2009) which firstly included quantitative data collection and analysis and secondly qualitative data collection and analysis. Therefore the quantitative phase (Phase I) carried more weight and was used to inform the qualitative phase (Phase II Interviews and Phase III Focus groups); mixing of the data took place when the quantitative results from Phase I were used to inform Phase II and III qualitative data collection as presented in Figure 2. Hence the quantitative and qualitative data are separate but connected via this informing nature.

The data analysis for the quantitative component consisted of a regression approach to assess the relationship between demographics including belonging to the "at risk" population, knowledge/understanding and individual risk perceptions (neighbourhood air effects on health) and AQHI adoption, and is further described in Chapter 3. For the qualitative component, interpretive description (Thorne, 2008) was used to assess knowledge and use of the AQHI as well as to uncover characteristics of the innovation which may be affecting AQHI adoption and can be used to direct interventions

that will increase AQHI uptake. It is further described in Chapter 4. As Figure 2 illustrates, findings from the quantitative and qualitative phases were interpreted together in order to develop the intervention strategy further described in Chapter 5.

Therefore, Phases I, II, and III in aggregate informed Phase IV, as illustrated in Figure 3. Recruitment posters, letters of information, consent forms, survey instruments, presentations and the interview guide are provided in the Appendices.

Figure 1. Conceptual Framework for Investigating the Factors Influencing AQHI Adoption in the City of Hamilton

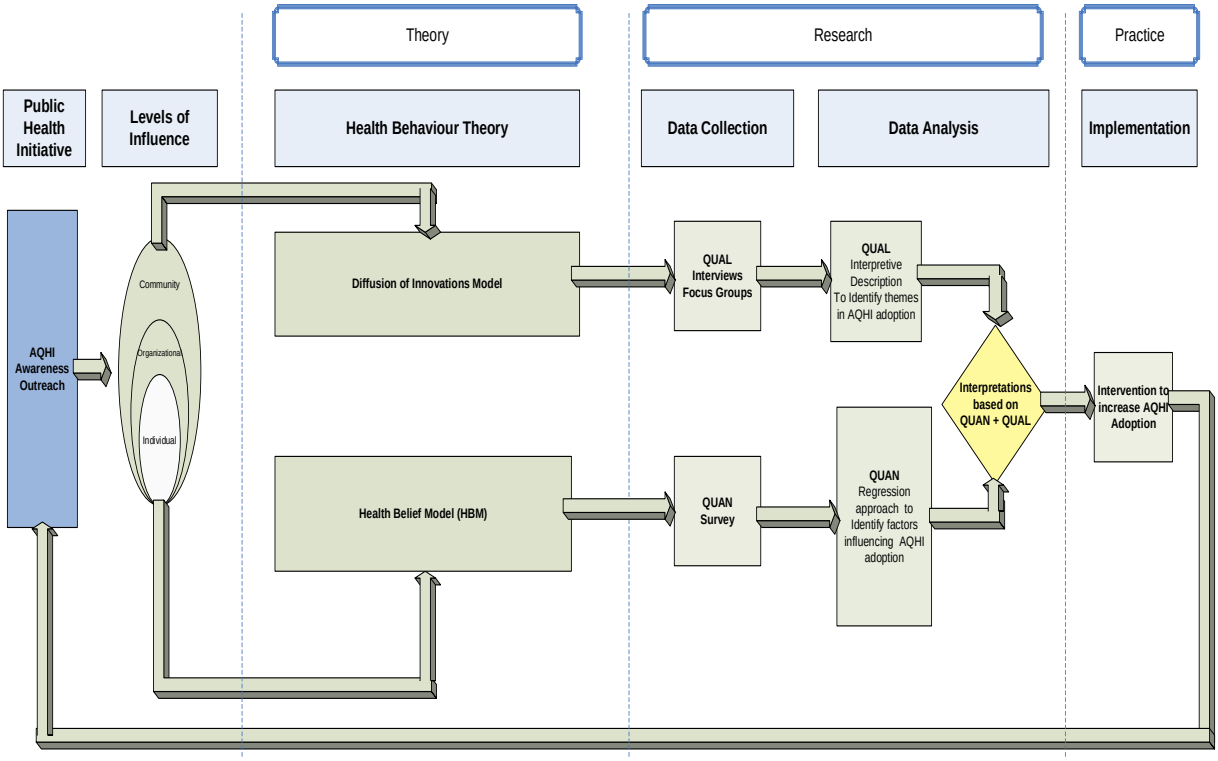
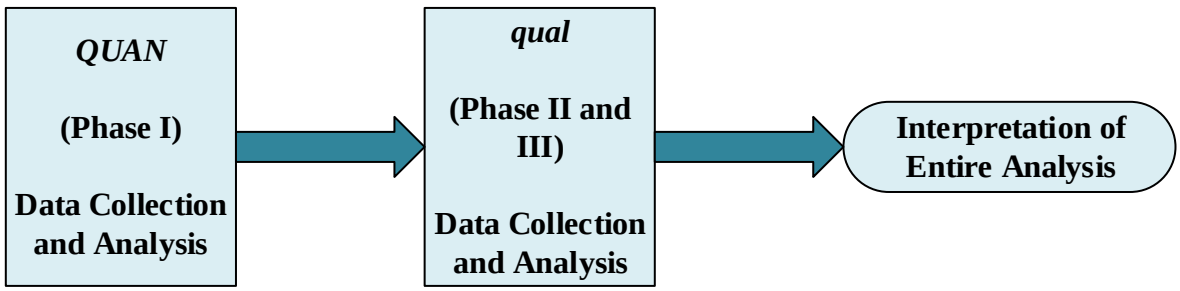


Figure 2. Mixed Methods Explanatory Sequential Design

Source: (Adapted from Creswell, 2009)



2.3 Phase I Recruitment

In Phase I, participants were recruited at special events and fairs taking place in the outdoor environment between June to the beginning of October 2012. Our convenience sample allowed us to quickly and inexpensively obtain participation from 707 City of Hamilton residents who were18 years of age and older visiting our City of Hamilton Public Health Services booth promoting public health initiatives including AQHI and completing a survey, with participants receiving AQHI promotional materials for participating. From Phase I we learned that 79% of the "at risk" population did not adopt the AQHI. Therefore, this finding that "at risk" populations were not significantly more likely than the general population to adopt the AQHI confirmed that focus on "at risk" populations and understanding why they were not more likely to adopt AQHI was the appropriate next phase. Moreover, our Phase I findings confirmed that SES differences needed be considered in Phase II.

2.4 Phase II Recruitment

In Phase II, key informants for the interviews were purposively recruited by reaching out to health care and service providers in both higher (further from industrial core and above the Niagara Escarpment) and lower SES (closer to industrial core and below the Niagara Escarpment) areas of Hamilton in mid-October of 2012. The selection of health care and service providers across lower and higher SES areas was designed to

account for spatial variations in air pollution concentrations, differences in perception of air pollution and health and health disparities that exist according to city divisions and SES. Potential interview participants were contacted by phone and those who expressed interest were either emailed an information sheet and consent form or they were hand delivered to respective work sites. Our key informant interviews were conducted face-to-face at each participant's work site and scheduled based on the participants' availability. The Phase II interviews confirmed the importance of exploring both health care and service providers' knowledge of AQHI along with the facilitators and barriers to AQHI adoption with that of their respective "at risk" populations'; hence Phase III focus groups were undertaken.

2.5 Phase III Recruitment

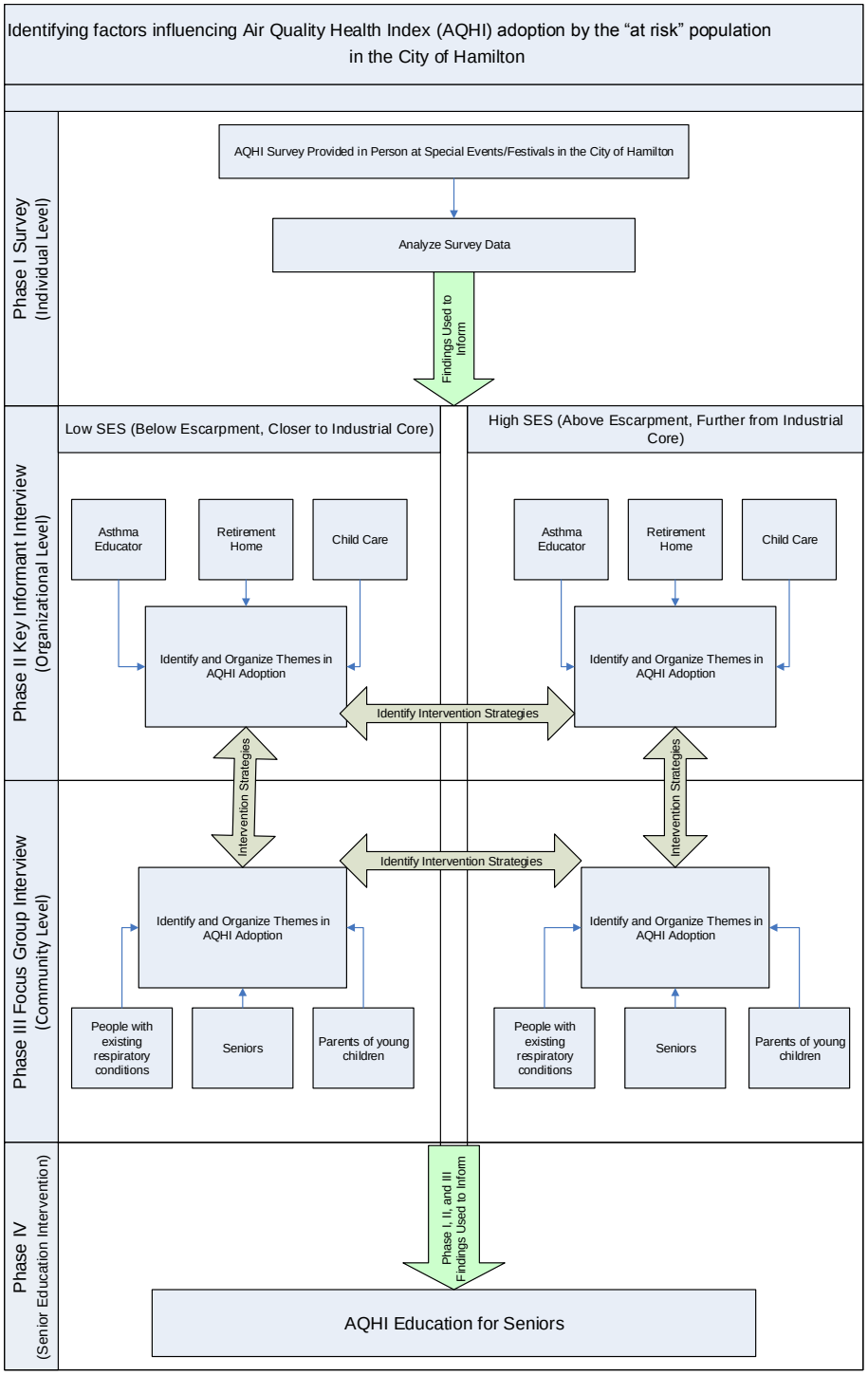
In Phase III, we worked with health care and service providers to recruit their respective "at risk" populations and explore AQHI knowledge along with facilitators and barriers to AQHI adoption in November of 2012 to April 2015. It is important to point out that the majority of focus groups including those with parents of young children and older adults (≥65 years) were conducted in November of 2012. Because we wanted to ensure that the participants with existing respiratory conditions had a clinical diagnosis of their respiratory condition (i.e. asthma, COPD) we only recruited participants forwarded by the health care providers servicing respiratory care patients in higher and lower SES areas of Hamilton. Therefore, recruitment of these participants took longer, with the

focus group of participants in the higher SES area being conducted in June of 2014. Recruitment to the focus group in the lower SES area took even longer, and was conducted in June 2015. Findings from Phase III confirmed that focus on the "at risk" population of older (≥ 65 years), lower SES adults was the most appropriate starting point with respect to an intervention to increase AQHI adoption in Hamilton. This was determined based on the finding that this group had the lowest level of AQHI knowledge which according to health behaviour theory is the first step in the adoption process (Glanz, 2008).

2.6 Phase IV Recruitment

In Phase IV, we recruited older adult (≥ 65 years) participants living in affordable housing with the assistance of the recreation coordinator for the seniors' programs in the City of Hamilton and the community relations workers for each of the affordable housing buildings from June 2014 to October 2014. We placed recruitment posters in nine seniors' buildings throughout the city. Interested older adults signed up for the education sessions with the community relations worker at each corresponding site. It is important to point out that we had difficulty recruiting older adults (≥65 years) living in affordable housing located in lower SES neighbourhoods and had to rescheduled at least once and sometimes two or three times before participants were engaged and agreed to attend.

Figure 3. AQHI Research Overview



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Chapter 3: Factors Influencing Health Behaviours in Response to the Air Quality Health Index: A Cross-Sectional Study in Hamilton, Canada

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Radisic, S., Newbold, K.B., Eyles, J., Williams, A., (2016). Factors Influencing Health Behaviours in Response to the Air Quality Health Index: A Cross-Sectional Study in Hamilton, Canada. *Environmental Health Review*, 59(1): 17-29.

Abstract

Research associating adverse health effects with air pollution exposure is robust. Public health authorities recognize the need to implement population health strategies that protect public health from air pollution exposure. The Air Quality Health Index (AQHI) is a public health initiative that is intended to protect public health from exposure to air pollution. The aim of this research was to identify and explain factors influencing AQHI adoption at the individual level and to establish intervention strategies. A cross-sectional survey with both quantitative and qualitative questions was administered in Hamilton, Canada during the months of June to October 2012. Logistic regression was used to analyze the quantitative data along with coding, and the Health Belief Model (HBM) is used to explore the qualitative data. Demographics (gender, age, education, area of residence), knowledge/understanding and individual risk perceptions (neighbourhood air effects on health) were found to be significant predictors of AQHI adoption. The perceived benefits of AQHI adoption included protection of health for self and those cared for via familial and/or occupational duties. While perceived barriers of AQHI adoption included lack of knowledge about where to check and lack of time required to check and follow AQHI health messages. Also, self-efficacy was uncovered as a factor influencing AQHI adoption. Accordingly, increases in AQHI adoption could be achieved via increasing AQHI knowledge among low SES females, communicating the benefits of AQHI adoption to "at risk" populations and implementing supports for males to follow AQHI health messages.

Keywords: public health; air pollution; Air Quality Health Index (AQHI); health behaviour; Health Belief Model (HBM); socioeconomic status (SES); environmental risk perceptions

3.1 Introduction

Air pollution is an environmental health issue receiving a great deal of attention because of the detrimental effects it has on population health (WHO, 2014). Research has consistently found adverse respiratory and cardiovascular health effects associated with air pollution exposure (Dockery et al. 1993; Pope et al. 2002; Zanobetti et al. 2009). Consequently, the World Health Organization (WHO) acknowledged outdoor air pollution as a human carcinogen (IARC, 2013).

Public health authorities recognize the need to implement population health strategies that protect public health from air pollution exposure. In Canada, the Air Quality Health Index (AQHI) is a health protection tool develop by the federal government (www.airhealth.ca) to provide air quality and health information such that the public can implement health protective behaviours (reducing and/or rescheduling outdoor activity) and decrease exposure to outdoor air pollution (Environment Canada 2013).

The AQHI is a comparatively easy to understand 10-point scale (low risk 1-3, medium risk 4-6, high risk 7-10, very high risk greater than 10) (Environment Canada 2013). Unlike the Air Quality Index (AQI) which was based on six pollutants (ozone (O_3), fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), total reduced sulphur (TRS)) and that communicates the single worst pollutant, the AQHI communicates the cumulative health risks for the pollutants in

the index (O_3, NO_2, $PM_{2.5}$) known to be hazardous to human health. Hence, the AQHI is considered best suited to communicate health risks associated with air pollution (Environment Canada 2013). The AQHI provides health messages for each category of health risk advising the public to implement health protective behaviour for both the "at risk" (young children, elderly and those with pre-existing respiratory and/or cardiovascular conditions) and general populations (Table 1). Therefore, adopting the AQHI as health protective behaviour would require an individual to be: 1) aware of AQHI, 2) check AQHI numbers, and 3) follow AQHI health messages.

As one of the original theories of health behaviour, the Health Belief Model (HBM) is also one of the most extensively used to explain health behaviour (Glanz et al. 2008). Developed to address public health concerns in the 1950s, (Hochbaum 1958; Rosenstock 1974) the model consists of six constructs which explain why individuals will participate in behaviour designed to prevent adverse health effects, including: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. The model is intuitive in the sense that it claims if a person believes he/she is susceptible to an exposure (i.e., air pollution), believes that engaging in a course of action available to him/her (i.e., AQHI adoption) would be beneficial in reducing either susceptibility to or severity of the exposure, and believes that the benefits of engaging in the action (i.e., prevention of adverse health effects) prevail over the costs of action (i.e., time commitments checking AQHI), he/she will engage in the action that is considered to decrease his/her risk (Glanz et. al. 2008). The model has also been effectively used to

explain and guide public health intervention strategies including breast cancer screening (Legler et al. 2002), injury prevention (Trifiletti et al. 2005) and HIV/AIDS-linked behaviours (Noar et al. 2009). Thus, the HBM can be used to explain AQHI adoption and guide intervention strategies.

Many studies have documented the detrimental effects of air pollution on health but Semenza et al. (2008) point out that there are few studies (Stieb et al. 1996) which examine the effects of air quality information on health behaviour. This study examines the effects of air quality information on health behaviour by determining what factors influence the adoption of the AQHI in the City of Hamilton, as an example.

3.2 Methods

3.2.1 Survey Instrument

The questionnaire developed for the study was based on the Health Belief Model (HBM) constructs and individual characteristics identified as key components of environmental risk perception including: demographics, socioeconomic status (SES) and health status (Elliott et al. 1999; Eyles et al. 2009; Simone et al. 2012; Wilson et al. 2009). The survey included both quantitative and qualitative questions to identify and explain AQHI: awareness, checking, following of health messages and adoption. AQHI awareness was assessed with the survey question: "Have you heard of the Air Quality Health Index (AQHI)?" To assess if participants were checking AQHI, the question: "Do

you check the Air Quality Health Index (AQHI)?" was asked. In addition, to assess if participants were following AQHI health messages, the survey asked: "Do you follow AQHI Health Messages which tell you when to consider reducing or re-scheduling outdoor physical activity?" Responses to all three questions (AQHI awareness, AQHI checking, AQHI following) were used together to establish AQHI adoption.

3.2.2 Study Area

The City of Hamilton, Ontario, Canada is an industrial city consisting of a population of over 519,000 people, with 84.1% speaking English in the home (Statistics Canada 2012). Several studies have identified that there are spatial variations in air pollution concentrations in the City (Buzzelli et al. 2003; Jerrett et al. 2001; Wallace et al. 2010). A number of factors contribute to the spatial variability of air pollution including: vehicles/traffic, industry/facilities, meteorological conditions/atmospheric inversions, and the geographical upper and lower city divide by the Niagara Escarpment, potentially entrapping pollutants (Wallace et al. 2010).

The City has experienced a demographic shift with wealthier individuals moving out of the lower city and into the higher SES suburban areas; leaving those individuals of lower SES in the lower City (DeLuca et al. 2012). To determine if demographics, SES and health status are influencing AQHI adoption, this study applied the same 4 quadrant division of the urban areas used previously by other researchers, studying air pollution and health in Hamilton (Barakat-Haddad et al. 2013; Kerigan et al. 1986). The 4 urban

areas include: East Lower (EL), West Lower (WL) (merged Industrial Core (IC)), East Upper (EU) and West Upper (WU) (Figure 1). In addition to the 4 urban areas, this study includes 5 suburban areas: Ancaster/Dundas/Flamborough (ADF), Stoney Creek (SC) and Glanbrook (GB). Due to the low response rate in the suburban areas of Ancaster, Dundas and Flamborough, they were combined to represent one suburban area for analysis purposes.

The use of the 4 quadrant urban area divisions along with the 3 additional suburban divisions accounts for spatial variations in air pollution (Wallace et al. 2010), demographic, socioeconomic and health differences (DeLuca et al. 2012) which, according to the HBM, are linked to perceived threat (perceived susceptibility plus perceived severity), benefits, barriers and self-efficacy. Therefore, the division of the city into 7 distinct areas allows the HBM to explain and guide AQHI adoption in Hamilton.

3.2.3 Sample

Participants were recruited at fairs in the urban and suburban areas of the City during the months of June to October 2012. An AQHI promotional booth was set up where participants had the opportunity to participate by completing a paper and pencil survey. Inclusion criteria included being a City of Hamilton resident and at least 18 years of age and older. The study consisted of a convenience sample of 707 participants who received AQHI promotional materials (i.e. water bottle, Frisbee, beach ball) as compensation for participating. This research received ethics approval from the

McMaster University Research Ethics Board and informed consent from participants prior to conducting the study.

3.2.4 Data Analysis

There were two broad phases to the analysis. First, logistic regression analysis using SPSS (version 22) was used to predict AQHI awareness, checking, following and adoption from demographics, knowledge/understanding, individual perceptions and pre-existing conditions. The four dichotomous (yes/no) dependent variables included: AQHI awareness, AQHI checking, AQHI following, and AQHI adoption.

The independent variables used in the logistic regression are outlined in Table 2 along with the survey questions and coded responses. The independent variables include: gender, age, household income, education, and area of residence. Moreover, AQHI knowledge/understanding was included to determine if there was a difference between being aware of the term and understanding what it means. In addition, individual perceptions including those about neighborhood air quality and physical environment impacts on health along with the length of time of these perceptions were incorporated. Other individual perceptions included the amount of time participants estimated they spent outdoors and how they perceived their health status. The final independent variable included presence of pre-existing respiratory and/or cardiovascular conditions.

Second, qualitative questions were incorporated in the survey to give further insight into AQHI awareness, checking, following, and adoption. By focusing on knowledge/understanding of AQHI, reasons attributed to checking/not checking and

following/not following AQHI, HBM constructs including: perceived threat, benefits, barriers, cues to action and self-efficacy were identified and explained. Content analysis and descriptive codes (Hay 2010) were used to organize the qualitative data according to the HBM constructs.

3.3 Results

3.3.1 Sample Characteristics

Table 3 displays the characteristics of the sample including: gender, age, education, household income, area of residence, and presence of pre-existing respiratory and/or cardiovascular conditions. The gender distribution was uneven, with 29% male and 68% female. The age range of participants was normally distributed with the greatest proportion (23%) in the age brackets between 45 and 54; this is fairly consistent with the age distribution in Hamilton (Statistics Canada, 2013). The "at risk" population representing the elderly (65 years of age and over) accounted for 11% of the sample which is slightly lower than the 16% (Statistics Canada, 2013) found in Hamilton. The majority of participants had a household income of $21 000- $50 000 while the minority had a household income of $81 000 or more; this is consistent with that in Hamilton (Statistics Canada, 2013). The greatest proportion of participants was high school (35%) and college educated (33%) which is consistent with that found in Hamilton (Statistics Canada, 2013). All of the urban and suburban areas in the City were represented. Twenty two percent of the participants in the East Lower urban area (lower SES) made up the

sample; this is consistent with the population distribution in that area for Hamilton (Statistic Canada, 2012). However, only 4% of the sample resided in the suburban areas (higher SES) of Ancaster, Dundas and Flamborough which is much lower than the 20% that make up the population distribution in that area of Hamilton (Statistics Canada, 2012). Within this sample, 25% reported that they have a pre-existing respiratory condition with asthma the most commonly reported; this is higher than the prevalence rate of 12.93% reported for the province of Ontario (Crighton et al. 2012). Nine percent of the participants indicated that they have a pre-existing cardiovascular condition with experiencing a heart attack as the most commonly reported; this is higher than the 5% of heart disease self reported in Ontario (Heart and Stroke Foundation 2014).

3.3.2 Quantitative Data

Table 4 presents the logistic regression results for AQHI awareness, AQHI checking, following AQHI health messages, and AQHI adoption. Each of the logistic regression results is discussed below.

AQHI Awareness

Sixty percent (425/707) of participants indicated that they were aware of AQHI. Logistic regression predicting AQHI awareness identified that having a high school ($p<0.05$) and/or college education ($p<0.05$), living in the suburban areas of Ancaster,

Dundas, Flamborough ($p<0.05$) and Stoney Creek ($p<0.05$) (higher SES areas), and knowing where to check the AQHI ($p<0.01$) are positively associated with being aware of AQHI. Conversely, being female ($p<0.05$), perceiving neighbourhood air as affecting health for the last 6 months ($p<0.05$) and not knowing or having an understanding of what AQHI means ($p<0.001$) are negatively associated with the probability of being aware of AQHI.

AQHI Checking

Thirty six percent (256/707) of participants reported that they know where to check for the AQHI, while only 27% (190/707) reported that they check AQHI. Of those who check AQHI, 27% (52/190) reported that they always check, 43% (81/190) reported that they check half the time and 8% (16/190) reported that they rarely check. Logistic regression predicting AQHI checking identified that being 35 to 44 ($p<0.05$), 45-54 ($p<0.01$) and 55-64 ($p<0.05$) years of age and knowing where to check ($p<0.001$) the AQHI are positively associated with the probability of checking AQHI numbers. However, perceiving neighbourhood air as affecting health for the last 10 years is negatively associated with the probability of checking AQHI numbers ($p<0.05$).

AQHI Following Health Messages

Forty three percent (303/707) of all participants reported that they follow AQHI health messages. However, 37% (113/303) of those who reported following AQHI health messages were not checking AQHI numbers; therefore, these individuals are relying on

cues other than AQHI to implement health protective behaviours. Logistic regression results indicate that being female ($p<0.05$), having an understanding of what the AQHI means ($p<0.05$), knowing where to check AQHI numbers ($p<0.05$) and residing in the West Lower area ($p<0.05$) of the City are positively associated with the probability of following AQHI health messages.

AQHI Adoption

Twenty percent (142/707) of the participants were aware of AQHI, check AQHI and follow AQHI health messages, and therefore have adopted AQHI. Within the "at risk" population (65 years and over and those with pre-existing respiratory and/or cardiovascular conditions), 79% (253/319) have not adopted the AQHI. Logistic regression predicting AQHI adoption identified that being 45 to 54 years of age ($p<0.05$), having an understanding of the AQHI means ($p<0.05$) and knowing where to check AQHI numbers ($p<0.01$) are positively associated with the probability of adopting AQHI.

3.3.3 Qualitative Data

The qualitative data collected from 707 surveys is presented below together with the quantitative questions they were designed to expand upon.

Knowledge/ Understanding of AQHI

In order to expand upon the quantitative question asking: "*Do you know what a High AQHI (7-10) means?*", participants were asked to explain what it means to them. Eighty four percent of participants responded to this open-ended question by expanding on aspects of limiting outdoor activity, identifying "at risk" populations and adverse health effects due to air pollution exposure. Participants explained that High AQHI (7-10) means: "One should take protective measures or limit outdoor activities" and "People with respiratory + other conditions impacted by high level". Participants explained adverse impacts on health and outdoor activity by indicating that: "It means I may have trouble enjoying activities outdoors because of breathing issues" and "That your breathing could be affected especially if you have breathing problems".

Although responses were consistent with the purpose of AQHI, confusion in messaging between the AQI and AQHI was apparent. Participants indicated that they believed high AQHI means: "Smog alert is out" and that "A health warning goes out to the media newspaper, radio, T.V. + internet to warn people with health conditions esp asthmatics + seniors". Unlike with the AQI, smog alerts and media advisories were not issued with the AQHI.

To further explore knowledge/understanding of AQHI and expand upon the quantitative question: "*Do you know where to check for daily Air Quality Health Index (AQHI)?*", participants were asked to explain "*where*" they check AQHI. Participants explained that they check the AQHI on the television, radio, websites, and in the newspaper. Specifically, the "Weather Network", local television news and local

newspapers were named as sources for AQHI information. Currently, the local news channel and the local newspaper do not post AQHI information in the City of Hamilton. Therefore, although participants were able to explain the purpose of the AQHI, there appears to be confusion between the AQI and AQHI, as well as, where to find AQHI information.

Reasons Attributed to Checking/Not Checking AQHI and Following/Not Following AQHI Health Messages

With the intention to further expand upon the quantitative question: "*Do you check the Air Quality Health Index (AQHI)?*", participants were asked to explain "*why or why not?*". Likewise, to further expand upon the quantitative question: "*Do you follow AQHI Health Messages which tell you when to consider reducing or re-scheduling outdoor physical activity*?", participants were asked to explain "*why or why not*".

Participants who checked AQHI and follow AQHI health messages explained that they perceived the benefits of checking and following health messages as those related to health protection for self and those they care for via familial and/or occupational duties. Participants indicated that they follow AQHI health messages because they want to ensure: "safety for kids" and because they "work with children, so I really need to be responsible of health & safety of myself and others".

Consistently, participants identified lack of knowledge as a perceived barrier to checking and following AQHI health messages. Participants indicated that they are not able to check and follow AQHI health messages because they: "Don't know where". An

additional barrier to checking and following health messages was lack of time. Participants explained that they: “Don’t always have time” and are “Too busy with children – the index won’t really influence my activities”. Moreover, participants described issues pertaining to self-efficacy as a reason for not checking and following AQHI health messages by responding: “Don’t know how”.

Reasons for not checking and following health messages varied among lower and higher SES participants. Those in the East Lower area (lower SES) indicated that they do not check and follow AQHI health messages since they: “cannot control it” and “cannot change it”. This suggests that issues concerning empowerment should be explored. While those in the suburban areas (higher SES) of Ancaster, Dundas, Flamborough, Stoney Creek and Glanbrook indicated that checking and following AQHI health messages is: “not a high priority” and “not too much of an issue in the country over the escarpment”. This suggests that issues around optimism bias should be explored.

In addition, participants indicated that they do not check and follow AQHI health messages because they rely on sensory cues that they can “visually see and hear”. Moreover, they indicated that they do not check and follow AQHI health messages because they “just go by self smarts” and “ Sometimes – don’t really need to – can tell by way air looks”. Another participant indicated that checking AQHI is not necessary because: “I use the temperature to determine”. Moreover, reliance on media advisories as a cue to modify health behaviour was provided as a reason for not checking and following health messages. Participants indicated that “If on news” and “Only if mentioned on radio” they would implement health protective behaviors.

3.4 Discussion

Therefore, reasons for checking and following AQHI included acknowledgement of the perceived threat of adverse health effects from exposure to air pollution and the perceived benefits of health protection for self and those cared for via familial and/or occupational duties. Barriers to checking and following health messages included: lack of knowledge and time, and reliance on sensory cues and media advisories. Reasons for not checking and following health messages did vary between lower and higher SES groups. Moreover, self-efficacy was apparent as a reason for not checking and following AQHI health messages.

As the HBM and previous research (Elliott et al. 1999; Eyles et al. 2009; Simone et al. 2012; Wilson et al. 2009) proposed, demographics (gender, age, education, area of residence), knowledge/understanding and individual perceptions (neighborhood air effects on health) were significant predictors of AQHI awareness, checking, following health messages and adoption in this study. The qualitative data helped explain these predictors and guides intervention strategies to increase AQHI adoption.

The findings suggest that intervention strategies must account for gender differences in awareness and following health messages. This study's findings are consistent with a US study on the Air Quality Index (AQI) and awareness which found that women were less likely to be aware than men (Johnson 2012). Thus, the intervention strategy should focus on making women aware through promotional channels (i.e. women's health/fitness magazines).

Although females were less aware of the AQHI than males, they were more likely

than males to follow AQHI health messages. Researchers who examined sun protective behaviour also found that females were more likely to engage in the health protective behaviour than males(Buller et al. 2011); as did researchers who examined health protective behaviors in response to West Nile virus (Elliott et al. 2008). Therefore, an intervention strategy should focus on encouraging males to reduce or re-schedule outdoor physical activity according to the AQHI; this messaging could be done with the assistance of health professionals since studies have found that people are more likely to implement health protective behaviors in response to poor air quality when informed by health professionals (Wen et al. 2009).

In addition, intervention strategies must focus on increasing knowledge/understanding of AQHI. As Elliott et al. (1999) found when examining AQI awareness in Hamilton, recognizing the term "AQHI" does not necessarily indicate knowledge/understanding of what it means. Accordingly, the intervention strategy must clearly define the purpose of the AQHI; this will address confusion between AQI and AQHI identified. The need to increase knowledge/understanding is further supported by the fact that being "at risk" (65 years of age and over; having a pre-existing respiratory and/or cardiovascular condition) was not found to be a significant predictor of AQHI adoption; participants belonging to the "at risk" population in this study did not perceive severity nor believe that they may be more sensitive to air pollution than the general population. Therefore, intervention strategies must clearly define the "at risk" populations such that they are able to self-identify and understand that they are considered "at risk". Moreover, increasing the public's knowledge/understanding with respect to finding and

using AQHI numbers to address self-efficacy issues must be considered.

Furthermore, interventions strategies must account for variations in environmental risk perceptions found in lower and higher SES areas of the city (Elliott et al. 1999; Eyles et al. 2009; Simone et al. 2012; Wilson et al. 2009). Differences in perceived threat and AQHI awareness have been identified as reasons for not adopting AQHI. As other studies have found with AQI (Johnson 2012), this study has found a higher level of AQHI awareness among individuals of higher SES. Moreover, the data suggests that individuals who perceive their neighborhood air impacting their health for an extended period of time (10 years) may rely on sensory cues (see, smell, feel) to implement health protective behaviors as opposed to AQHI numbers. This is consistent with other studies that found sensory cues prevail over AQI (Bickerstaff et al. 2001; Bush et al. 2001). This study suggests that issues concerning empowerment are important in understanding why individuals in lower SES are not adopting AQHI while issues concerning optimism bias are important in understanding why individuals in higher SES are not adopting AQHI.

The finding that individuals in the West Lower area were more likely to follow AQHI health messages than those in the East Lower area supports community engagement as a successful approach to health promotion and community empowerment (Milton et al. 2011). The West Lower area of the city has been engaged in different environmental and health promoting initiatives such as the "Bike Share" initiative (City of Hamilton 2014).

To address neighbourhood area variations in perceived threat and AQHI awareness, the intervention strategies should provide AQHI information at a

neighborhood scale. By providing AQHI information that represents conditions within the public's immediate environment, issues of empowerment in the lower SES and optimism bias in the higher SES can be addressed.

Finally, local AQHI media advisories should be incorporated since participants indicated that they rely on media advisories as cues to implement health protective behaviours. The AQHI was designed as a self-calibration tool such that individuals could determine what level is a detriment to their individual health. As such, this varies between individuals. Taking individual variability into account and applying the precautionary principle, AQHI (7-10) High Health Risk levels at which it is recommended that the "at risk" population "reduce or reschedule strenuous" (Environment Canada 2013) outdoor activity could be proposed as a level for which public media advisories are provided.

3.4.1 Limitations

Although our convenience sample was fairly representative with respect to distribution of age, income, education and population according to city divisions (Statistics Canada, 2013; Statistics Canada, 2012), over representation of females and under representation in higher SES suburban areas may have contributed to self-selection sampling which may have impacted results.

Additionally, as with all studies using surveys, recall and response bias may be impacting the results. Moreover, even though the qualitative questions encouraged participants to expand upon responses instead of simply agreeing, acquiescence bias may be impacting the results.

Another limitation includes the HBM not accounting for emotional aspects of behaviour (Glanz et al. 2008) and impacts of past behaviours (habits) as predictors of future behaviours (Quellette and Wood 1998).

3.5 Conclusion

As HBM posits, once AQHI knowledge is gained, perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy need to be considered with respect to AQHI adoption. Increasing AQHI knowledge is critical for AQHI adoption to occur. Particular focus on increasing AQHI knowledge should be given to females in lower SES areas

Accordingly, with respect to perceived threat (perceived susceptibility and severity), risk to health from outdoor air pollution exposure must be clearly communicated such that the benefit of using the AQHI to decrease the potential for adverse health effect outweighs the barrier of time commitment required to check AQHI and follow AQHI health messages. Particular attention should be given to "at risk" populations so that they are able to accurately perceive threat to health from exposure to air pollution and implement health protective behaviour accordingly. Additionally, attention to increasing the likelihood of males following AQHI health messages should to be considered.

These intervention strategies account for AQHI adoption at the individual level. Intervention strategies which examine AQHI adoption at the organizational and

community levels and consider empowerment, community engagement and optimism bias are recommended to develop a comprehensive public health approach to increase AQHI adoption (Glanz, 2008).

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Table 1. Air Quality Health (AQHI) Messages (Source: Environment Canada, 2013)

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	**General Population**
Low	**1 - 3**	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	**4 - 6**	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	**7 - 10**	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	**Above 10**	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation

*People with heart or breathing problems are at greater risk.

Table 2. Independent Variables and Survey Questions

Independent Variable	Survey Question	Coded Responses
Gender	What is your sex?	Male ☐ Female
Age	What is your age?	18-24 ☐ 25-34 35-44 45-54 55-64 65 and over
Income	What is your household income?	Under $20,000 $21,000-$50,000 $51,000-$80,000 $81,000 and over
Education	What is the highest level of education you completed?	Elementary School High School Trade College University
Area of Residence	What is your postal code? Where do you live?	Ancaster Dundas Flamborough Glanbrook Hamilton Stoney Creek Other Please Specify
AQHI Knowledge/Understanding	Do you know what a **High AQHI (7-10)** means?	Yes No Not Sure
Know Where to Check	Do you know where to	Yes No Not Sure

	check for daily **Air Quality Health Index (AQHI)**?	
Perceived Neighborhood Air Effects on Health	Do you think the **air** in your neighbourhood affects your health?	Yes No Not Sure
Length of Time Perceive Neighborhood Air Effects on Health	How long have you felt this way about the air in your neighbourhood?	Last week Last month Last 6 months Last year Last 5 years Last 10 years Other Please Specify
Perceived Neighborhood Physical Environment Effects on Health	Do you think the **physical environment** (i.e. **buildings**, **vehicles/traffic**, **trees**, **etc.**) in your neighbourhood affects your health?	Yes No Not Sure
Length of Time Perceive Neighborhood Physical Environment on Health	How long have you felt this way about the physical environment in your neighbourhood?	Last week Last month Last 6 months Last year Last 5 years Last 10 years Other Please Specify
Time Spent Outside	How much of your time**,** in the summer, is spent **outside** doing **physical activity**?	Most of my time Some of my time Hardly any of my time None of my time

Health Status (Self-Reported)	How would you describe your current overall health?	Very Good Good Fair Poor Very Poor
Pre-Existing Respiratory Condition	Do you have any existing respiratory (breathing) conditions?	Yes No Not Sure
	If **YES**, which condition(s)? Check as many as apply.	Asthma Chronic Obstructive Pulmonary Disease (COPD) Bronchitis Emphysema Other Please Specify
Pre-Existing Cardiovascular Condition	Do you have any existing cardiovascular (heart) conditions?	Yes No Not Sure
	If **YES**, which condition(s)? Check as many as apply.	Angina Previous Heart Attack Congestive Heart Failure Arrhythmia Other Please Specify

Table 3. Sample Characteristics

Characteristic	N=707	%
Gender		
Males	204	29
Females	479	68
Missing	24	3
Age (years)		
18-24	56	8
25-34	118	17
35-44	155	22
45-54	163	23
55-64	138	19
65 and over	77	11
Missing	0	0
Income		
Under $20,000	157	22
$21,000-$50,000	194	27
$51,000-$80,000	159	23
$81,000 or more	125	18
Missing	72	10
Education		
Elementary	23	3

High School	249	35
Trade	41	6
College	235	33
University	154	22
Missing	5	1
Area of Residence		
East Lower	154	22
West Lower	65	9
West Upper	135	19
East Upper	85	12
Ancaster/Dundas/Flamborough	28	4
Stoney Creek	117	17
Glanbrook	92	13
Missing	31	4
Know What AQHI Means		
Yes	244	34
No	298	42
Not Sure	124	18
Missing	41	6
Know Where to Check AQHI		
Yes	255	36
No	322	46

Not Sure	95	13
Missing	34	5
Time Spent Outside		
Most	290	41
Some	338	48
Hardly Any	56	8
None	4	1
Missing	19	2
Pre-Existing Respiratory Condition		
Yes	179	25
No	525	74
Missing	3	1
Pre-Existing Cardiovascular Condition		
Yes	63	9
No	636	90
Missing	8	1

Table 4. Binary Logistic Regression Predicting AQHI Awareness, Checking, Following and Adoption

	AQHI Awareness (n=426)		AQHI Checking (n=418)		AQHI Following (n=394)		AQHI Adoption (n=419)	
Predictor	B	Odds Ratio	B	Odds Ratio	B	Odds Ratio	B	Odds Ratio
Gender								
Male	Reference							
Female	-.740	.477*	.239	1.271	.765	2.148*	.328	1.389
Age								
18-24	Reference							
25-34	.201	1.223	1.006	2.735	-.563	.570	.492	1.635
35-44	.182	1.200	1.526	4.601*	-.238	.789	1.339	3.815
45-54	-.003	.997	2.095	8.129**	.666	1.947	1.778	5.917*
55-64	.215	1.240	1.814	6.136*	-.322	.725	.940	2.561
65 and over	-.418	.658	1.420	4.136	-.445	.641	.135	1.145
Income								

Under $20,000	Reference							
$20,000-$50,000	.024	1.024	-.268	.765	-.177	.837	-.074	.929
$51,000-$80,000	.325	1.384	-.293	.746	-.507	.602	-.324	.723
$81,000 or more	.288	1.333	-.339	.712	-.661	.516	-.336	.715
Education								
Elementary School	Reference							
High School	2.521	12.436*	.224	1.251	-.037	.963	-.719	.487
Trade	.619	1.858	-.132	.876	-1.373	.253	-1.077	.341
College	2.117	8.302*	.583	1.791	.082	1.086	-.283	.754
University	1.134	3.109	.011	1.011	.407	1.502	-.914	.401
Area of Residence								
EL	Reference							
WL	.874	2.396	.003	1.003	1.170	3.221**	.307	1.359
WU	.652	1.919	-.207	.813	.247	1.280	-.625	.535
EU	.593	1.809	-.434	.648	-.264	.768	-.764	.466
ADF	1.770	5.871*	.184	1.202	.879	2.408	.587	1.798

SC	1.133	3.105*	.055	1.057	.648	1.913	.005	1.005
GB	.987	2.683	.398	1.489	.710	2.035	.180	1.198
Know What AQHI Means								
Not Sure	Reference							
Yes	1.456	4.289**	.523	1.686	.690	1.994	1.046	2.845*
No	-1.403	.246#	-.214	.807	-.777	.460*	-.685	.504
Know Where to Check								
Not Sure	Reference							
Yes	.805	2.236	2.654	14.214#	1.314	3.723**	1.835	6.266**
No	-1.408	.245**	-.875	.417	-.149	.862	-1.432	.239*
Air Affects Health								
Not Sure	Reference							
Yes	.479	1.615	.707	2.027	.841	2.318	.710	2.034
No	.980	2.664	.607	1.835	.657	1.930	.557	1.745

Length of Time Perceive Air Affects Health								
Last Week	Reference							
Last Month	-1.583	.205	-3.097	.045	-2.370	.093	-17.258	.000
Last 6 Months	-4.103	.017*	-2.997	.050	-.756	.470	.628	1.874
Last Year	-3.111	.045	-2.195	.111	-.348	.706	.076	1.079
Last 5 Years	-2.975	.051	-2.241	.106	-1.166	.311	.094	1.099
Last 10 Years	-2.736	.065	-3.332	.036*	.157	1.170	-.011	.989
More than 10 Years	-1.998	.136	-2.686	.068	.820	2.272	1.080	2.945
Other	-3.442	.032	-2.708	.067	.229	1.257	-.243	.784
Physical Environment Affects Health								
Not Sure	Reference							
Yes	.209	1.232	.081	1.084	-.155	.857	-.341	.711
No	-.622	.537	.371	1.450	-.454	.635	-.327	.721

Length of Time Perceive Physical Environment Affects Health								
Last Week	Reference							
Last Month	-.446	.640	1.829	6.230	2.795	16.361	-15.134	.000
Last 6 Months	.825	2.282	2.397	10.992	1.323	3.754	-.441	.643
Last Year	1.302	3.675	1.376	3.960	-.029	.971	-1.586	.205
Last 5 Years	.622	1.863	2.214	9.149	.912	2.489	-.771	.463
Last 10 Years	.318	1.375	2.796	16.376	-.198	.820	-.849	.428
More than 10 Years	-.961	.382	2.838	17.087	-.557	.573	-1.763	.171
Other	1.618	5.044	2.373	10.734	-2.919	.054	-2.600	.074
Time Spent Outside								
None	Reference							
Most	.542	1.720	-.074	.928	-.376	.687	-.794	.452
Some	1.475	4.369	-.173	.841	.353	1.424	-.800	.449

Hardly Any	1.997	7.369	-1.318	.268	-.318	.728	-1.348	.260
Health Status (Self-Reported								
Very Good/Good	Reference							
Fair/Poor/Very Poor	-.214	.807	.447	1.564	.130	1.139	.128	1.137
Pre-Existing Respiratory Condition								
Yes	.488	1.630	.508	1.662	-.337	.714	.051	1.052
No	Reference							
Pre-Existing Cardiovascular Condition								
Yes	.695	2.003	-.411	.663	.594	1.811	-.203	.816
No	Reference							
Cox and Snell R^2	.416		.395		.316		.357	
Nagelkerke R^2	.573		.560		.422		.543	

Significance levels: $^{*}p<0.05$, $^{**}p<0.01$, $^{\#}p<0.001$

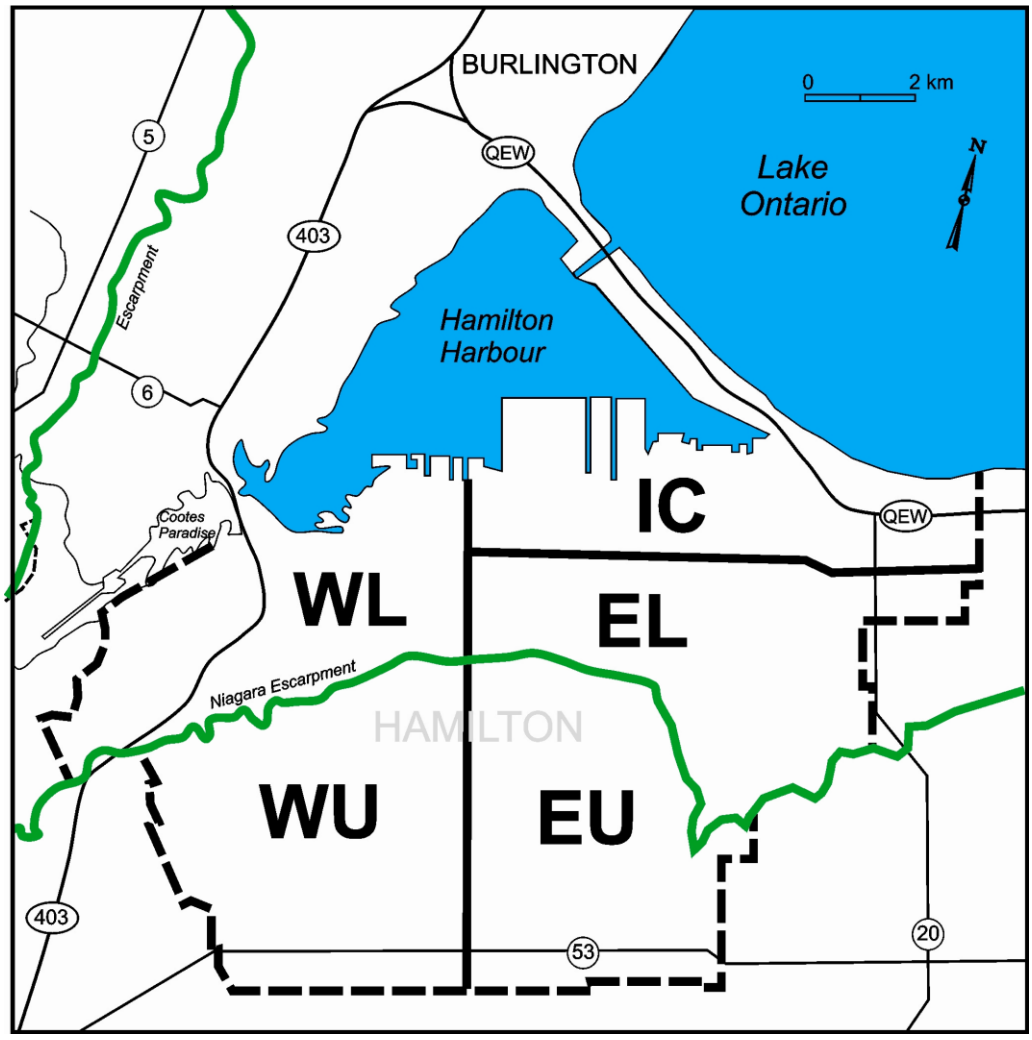

Figure 1. Division of Urban Areas
(Source: Barakat-Haddad et al. 2013; Kerigan et al. 1986)

Chapter 4: Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): a qualitative study

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Radisic S & Newbold KB. (2016). Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): a qualitative study. *BMC Health Services Research*. 16(107). DOI: 10.1186/s12913-016-1355-0

Abstract

Background: The Air Quality Health Index (AQHI) provides air quality and health information such that the public can implement health protective behaviours (reducing and/or rescheduling outdoor activity) and decrease exposure to outdoor air pollution. The AQHI's health messages account for increased risk associated with "at risk" populations (i.e. young children, elderly and those with pre-existing respiratory and/or cardiovascular conditions) who rely on health care and service providers for guidance. Using Rogers' Diffusion of Innovations theory, our objective with respect to health care and service providers and their respective "at risk" populations was to explore: 1) level of AQHI knowledge; 2) factors influencing AQHI adoption and; 3) strategies that may increase uptake of AQHI, according to city divisions and socioeconomic status (SES).

Methods: Semi-structured face-to-face interviews with health care (Registered Nurses and Certified Respiratory Educators) and service providers (Registered Early Childhood Educators) and focus groups with their respective "at risk" populations explored barriers and facilitators to AQHI adoption. Participants were selected using purposive sampling. Each transcript was analyzed using an Interpretive Description approach to identify themes. Analyses were informed by Rogers' Diffusion of Innovations theory.

Results: Fifty participants (6 health care and service providers, 16 parents, 13 elderly, 15 people with existing respiratory conditions) contributed to this study. AQHI knowledge, AQHI characteristics and perceptions of air quality and health influenced AQHI adoption. AQHI knowledge centred on numerical reliance and health protective intent but varied

with SES. More emphasis on AQHI relevance with respect to health benefits was required to stress relative advantage over other indices and reduce index confusion. AQHI reporting at a neighborhood scale was recognized as addressing geographic variability and uncertainty in perceived versus measured air quality impacting health. Participants predominantly expressed that they relied on sensory cues (i.e. feel, sight, taste) to determine when to implement health protective behaviors. Time constraints were identified as barriers; whereas local media reporting and wearable devices were identified as facilitators to AQHI adoption.

Conclusion: Increasing knowledge, emphasizing relevance, and reporting AQHI information at a neighborhood scale via local media sources and wearable devices may facilitate AQHI adoption while accounting for SES differences.

Keywords: population health, air pollution, Air Quality Health Index (AQHI), diffusion of innovations theory, socioeconomic status (SES)

4.1 Background

Air pollution is detrimental to public health and particularly to the "at risk" population including young children [1], seniors (≥65 years) [2] and individuals with existing respiratory and/or cardiovascular conditions [3] since it can adversely impact respiratory and cardiovascular systems [4-6]. The World Health Organization (WHO) estimated that 3.7 million people around the world died in 2012 as a result of outdoor air pollution exposure [7]. In Canada, between 2008 and 2031, air pollution attributed deaths have been predicted to rise 83% [8]. In the Organization for Economic Co-operation and Development (OECD) countries, the economic costs of air pollution were estimated to have reached 1.7 trillion dollars (US) in 2010 [9].

Therefore, strategies to protect the public from exposure to air pollution and adverse health effect are critical. The Air Quality Health Index (AQHI) is a risk communication tool developed to provide hourly air quality and health information such that the public can implement health protective behaviours, such as reducing and/or rescheduling outdoor activity and decrease exposure to outdoor air pollution [10]. The AQHI is a relatively easy to understand 10-point scale (low risk 1-3, medium risk 4-6, high risk 7-10, very high risk greater than 10) [10] which incorporates health messages according to health risk categories and accounts for the increased risk of "at risk" populations as presented in Table 1 [10].

As a health promotion tool, AQHI reporting in the City of Hamilton started in summer 2011, although it had been introduced in the City of Toronto slightly earlier in 2008 [11]. In the City of Hamilton, promotion of the AQHI included the use of various media sources such as television, newspaper, radio, transit shelters, billboards and website. As an employee of the City of Hamilton's Public Health Services, the first author (SR) participated in face-to-face outreach to promote the AQHI to the public including the at risk population by attending local festivals and fairs held throughout the city. Moreover, AQHI promotional material was delivered either in person by the first author and/or via mail to both health care and service providers with the responsibility of caring for at risk populations and included: child care facilities, retirement homes, respiratory health clinics, recognizing that health care and service providers are regarded as the top source of health information [12]. Therefore, adoption of the AQHI by both health care and service providers and the at risk populations in their care is essential to the health protection of those at increased risk from exposure to air pollution. It is important to explore how AQHI information is used by health care and service providers and relayed to others, including at risk populations, and how receptive these different groups are to the new tool. In spite of this, the factors facilitating its uptake within Hamilton, or elsewhere, have not been explored to date, limiting understanding of how best to implement the tool.

Health behaviour theory places risk perceptions at its core [13]; therefore, with respect to AQHI adoption, perceptions of air quality and health are at the heart of this health

protective behaviour. Moreover, diffusion of Innovations (DOI) theory [14] can be used to understand AQHI adoption by both health care and service providers and their respective at risk populations. In public health, diffusion of innovations has been used to better understand dissemination and implementation of interventions in various areas such as skin cancer [15], cardiovascular disease (CVD) [16], HIV/AIDS [17] and substance abuse [18]. However, concerns have been raised about the potential of diffusion of innovations to widen socioeconomic (SES) gaps which in turn increase health disparities in the population [14]. The theory maintains that adopters (i.e. health care and service providers and their respective at risk populations decide whether to adopt an innovation (i.e. AQHI) by weighing the benefits and barriers of the new innovation (i.e. AQHI) [14].

Accordingly, DOI theory outlines a five stage process [14] (Figure 1) that can be applied to AQHI adoption. The first stage is the knowledge stage which initiates the process; while the second stage is the persuasion stage which involves formation of a negative or positive attitude about the innovation (i.e. AQHI) via the perceived characteristics of the innovation including: relative advantage (degree to which the AQHI is better than the previous one), compatibility (degree to which the AQHI fits with existing values, past experiences and needs), complexity (degree to which the AQHI is perceived as being too difficult to understand and use), trialability (degree to which the AQHI can be experimented with before committing to using it) and observability (degree to which the results of using the AQHI are visible to adopters) [14].

The third stage is the decision stage where adoption or rejection of the innovation (i.e. AQHI) is considered, and the fourth stage is the implementation stage where the innovation (i.e. AQHI) is put into practice. The fifth stage is the confirmation stage, where reinforcement for the innovation-decision (i.e. adoption) already formed occurs.

Using Hamilton, Ontario as an example, and Rogers' Diffusion of Innovations (DOI) theory to inform AQHI adoption, this paper explores: 1) level of AQHI knowledge; 2) factors influencing AQHI adoption and; 3) strategies that may increase uptake of AQHI with respect to health care and service providers and their respective "at risk" populations according to city divisions and SES.

4.2 Methods

We used qualitative methods to bring forth more in-depth and contextualized meanings that are connected to the risk and the role of everyday experience in how people understand air pollution which the typical quantitative questionnaire-based approach fails to capture [19].

An Interpretive Description qualitative approach as described by Thorne [20] guided research design and analysis. This inductive analytic approach emphasizes use by health professionals who are interested in developing applied health knowledge and bridging the research-practice gap.

4.2.1 Ethical Permissions and Data Trustworthiness

This research received ethics approval from McMaster University Research Ethics Board. Additionally, an audit trail was used to document the steps taken throughout the duration of the study. All sessions were conducted by the first author (SR) who provided an overview of the study and the interview guide and reviewed ethical and procedural aspects for voluntary participation, audio recording, transcription and data validation. Participants were given the opportunity to ask questions about the research and each person completed a consent form prior to participating in the study. To increase trustworthiness of the results and establish credibility, transferability, dependability and confirmability we used: purposive sampling, member checking, triangulation, audio recorded data and an audit trail [21, 22].

4.2.2 Setting

Located at the western end of Lake Ontario, the City of Hamilton, Ontario is an industrial city consisting of a population of over 519, 000 people in 2016, with 84.1% speaking English in the home [23]. Several studies have identified that there are spatial variations in air pollution concentrations in the City [24-26] with a number of factors contributing to this spatial variability including [26] vehicles/traffic, industry/facilities, meteorological conditions/atmospheric inversions, and the geography of the city which is divided into an 'upper' and 'lower' city divided by the Niagara Escarpment, which potentially entraps pollutants in the lower SES areas, below the Niagara Escarpment, and closer to the industrial core (IC). From this point on in the paper, lower SES refers to the area below

the Niagara Escarpment and closer to the IC; while higher SES refers to the area above the Niagara Escarpment and further from the IC.

The City has experienced a demographic shift with wealthier individuals moving out of the lower city and into the suburban areas above the escarpment and to the west of the downtown core, leaving lower SES individuals in the inner lower City [27]. This pattern based on city divisions and SES has also been found in perceptions of air quality and health and incidence of adverse health conditions including respiratory related and cardiovascular related emergency room visits and certain cancers such as lung cancer [27-34].

4.2.3 Study Sample Selection

Purposive sampling was used to select health care and service providers and at risk populations in both lower and higher SES neighbourhoods. The selection of health care and service providers and their respective at risk populations across lower and higher SES areas was designed to account for spatial variations in air pollution concentrations, differences in perception of air pollution and health and health disparities that exist according to city divisions and SES.

Potential interview participants including: Registered Nurses (RN) working in supervisory positions in retirement homes, RNs working as Certified Respiratory Educators (CRE) in respiratory health clinics and Registered Early Childcare Educators

(ECE) working in supervisory positions in childcare facilities were contacted by phone. Those who showed an interest were either emailed an information sheet and consent form or they were hand delivered to respective work sites. Face-to-face interviews were scheduled based on the participants' availability and conducted at each participant's work site.

Focus group participants consisted of people with existing respiratory conditions, seniors (≥ 65 years) and parents of young children. Participants were recruited with the assistance of their respective health care and service providers at centres in both lower and higher SES areas. Participants either contacted the first author or their respective health care and service provider to confirm participation.

4.2.4 Data collection

In order to compare AQHI adoption in the at risk populations with their respective health care and service providers' adoption of the AQHI, data collection was conducted in two phases. The first phase consisted of interviews with health care and service providers while the second phase consisted of focus groups representing at risk populations (i.e. people with existing respiratory conditions, seniors and parents of young children); both phases included participants in lower and higher SES areas as presented in Figure 2. The collection of data in this manner allowed for information to be generated by both groups

such that any similarities and differences in AQHI knowledge, factors influencing AQHI adoption along with strategies to increase AQHI uptake could be explored.

Six interviews were conducted in October 2012. Interview participants consisted of supervisory staff including RNs working in licensed retirement homes, CREs working in respiratory health clinics and ECEs working in licensed childcare centres in both lower and higher SES areas. All interviews were conducted face-to-face at each of the respective worksites. Most lasted 30 minutes. The 6 interview participant characteristics are presented in Table 2.

Six focus groups were conducted between November 2012 and April 2015 ranging from 5 to 10 participants. The focus groups included representative members from each of the at risk populations from both lower and higher SES areas. Therefore, focus group participants consisted of people with existing respiratory conditions, seniors and parents of young children. All focus groups were conducted face-to-face in respiratory health clinics, public buildings, and recreation centres in Hamilton, and lasted t about 1 hour. The 44 focus group participant characteristics are presented in Table 3.

4.2.5 Interview/Focus Group Questions

The same questions were asked of the health care and service providers as well as the at risk populations, but the context was appropriately set with a parenthesis that included: "As a health care/service provider caring for people with exiting respiratory conditions/seniors/children or parent of a young child/senior/person with existing respiratory conditions…can you tell me from your perspective…" and then followed by the questions. Therefore, questions pertaining to AQHI knowledge included: *"Have you heard of the Air Quality Health Index (AQHI)?*" and *"Do you know where to check for daily Air Quality Health Index (AQHI)?"* Additionally questions exploring characteristics of the AQHI and potential barriers to adoption included: "*Do you check the Air Quality Health Index (AQHI)? Why or why not?"* and *"Do you follow the AQHI Health Messages which tell you when to consider reducing or re-scheduling outdoor physical activity? Why or why not?"* Furthermore, questions exploring perceptions of air quality and health included: *"Do you think the air in your neighborhood affects your health? Why or why not?"* In order to explore facilitators to AQHI adoption and strategies to increase AQHI uptake, participants were asked: *"What do you think can be done to encourage/promote the use of the AQHI?"*

4.2.6 Data analysis

According to Interpretative Description, data analysis involves four sequential cognitive processes: (1) comprehending everything one can about the setting and experiences of

participants, (2) synthesizing instances or events to describe composite patterns, (3) theorizing to develop explanations for synthesized data, and (4) recontextualizing findings to other settings and contexts [20]. Each participant who agreed to be contacted was provided with a transcript of their session and was asked to validate the accuracy, clarity and completeness of the data and to mark passages they did not want quoted directly. NVivo10 (QSR International), a qualitative analysis software was used to organize, manage and code the validated interview and focus group data. We used constant comparison of interview data with other interview data and focus group data, theory and literature. New codes developed and evolved through the analysis.

4.3 Results

Three broad categories evolved from analysis of the transcripts, including AQHI knowledge, factors influencing AQHI adoption and strategies to increase AQHI uptake. These categories, along with the various themes in each category, are summarized in Table 4 and further described with supportive quotes below.

4.3.1 AQHI Knowledge

Numerical Reliance

Participants expressed that AQHI knowledge centred on numerical reliance. When health and service care providers and their respective at risk populations described the AQHI, descriptions involved the use of numbers to either reflect risk or access to AQHI

information. To highlight health risks due to air pollution exposure and differences within the population, the respiratory health care provider in the lower SES area indicated that *"…it may not bother somebody when it's[AQHI] at 6."* Moreover, people with existing respiratory conditions in the higher SES area noted that AQHI numbers reflect risk and indicated that: *"The weather network website you can click right on it for risk for number air quality."* Numerical reliance was also apparent in reference to accessing AQHI information. The child care provider in the lower SES area recalled that the AQHI could be accessed: *"... on the Channel 47"* and people with existing respiratory conditions in the higher SES area concurred that: *"The weather channel has it every 10 minutes."*

Health Protective Intent

Participants also described the health protective intent of the tool. Health care and service providers described the AQHI as a health protection tool and identified that the AQHI could be used to protect the health of their respective at risk populations. The respiratory health care provider in the lower SES area indicated: *"Give them the tools for them to best manage their disease, go to the tools to avoid the triggers, smog is a trigger and we talk about it…"* Moreover, health protective intent of the AQHI was expressed by the child care provider in the higher SES area as follows: *"...check air quality to determine if any of our children that have asthma should be excluded from outdoor play and that kind of thing..."*

SES Differences

Through interview and focus group discussions, differences in AQHI knowledge according to SES were brought to light. Although respiratory health care providers in both lower and higher SES areas voiced AQHI knowledge, AQHI knowledge within their respective at risk populations varied with SES. People with existing respiratory conditions attending clinics in the higher SES area explained that AQHI information could be obtained on *"The Weather Channel."* However, people with existing respiratory conditions attending clinics in the lower SES area indicated that *"People don't even know what it [AQHI] is."* Moreover, the senior care provider in the higher SES area explained that information about air quality was obtained from *"…the news and the weather…"* However, the senior care provider in the lower SES area indicated that with respect to the AQHI: *"This is an entirely new thing for me."* This same pattern of AQHI knowledge was expressed by child care providers in higher and lower SES areas. The child care provider in the higher SES area indicated that AQHI knowledge was obtained from: *"I believe it was from the supervisor's network."* On the other hand, the child care provider in the lower SES expressed novelty of the AQHI with the following comment: *"Oh so you do have a website for that?"* However, seniors in both higher and lower SES areas expressed lack of AQHI knowledge. Seniors in the higher SES area enquired: *"Is this tied in with your heat alerts?"* And seniors in the lower SES area indicated that they "*…have never seen that index"*.

4.3.2 Factors Influencing AQHI Adoption

Relevance

Both health care and service providers and their respective at risk populations emphasized that the AQHI was not relevant to the protection of their health, with this lack of relevance creating a barrier to AQHI adoption. The child care provider in the higher SES area explained that currently with respect to AQHI: "*It doesn't feel like it's a priority"* since *"... you don't tend to get air quality emphasized as much in the media".* Seniors in the lower SES area expanded on the need to communicate AQHI relevance by suggesting that AQHI engagement should: *"Get them to understand what it is that index is trying to accomplish and then to relate it to self ..."*As well, parents of young children in the lower SES area stressed the need to communicate AQHI relevance since *"...people just don't have the importance of it."*

Index Confusion

Additionally, participants expressed index confusion between the AQHI and other indices as a barrier to AQHI adoption. Aside from the respiratory health care providers, confusion about what the AQHI was and how it differed from other indices such as the humidex (an index used in Canada that incorporates both heat and humidity to describe how hot the weather feels to the average person [35] were expressed by the senior and child care providers as well as all at risk populations even after learning about the tool. For example the senior care provider in the higher SES area expressed: *"Because I*

always think of the pollution index. They used to always do the pollution index…But now they don't even talk about the pollution." Index confusion was also expressed by the child care provider in the higher SES area who commented: *"But that's — again that goes back to the heat."* This same confusion was repeated by parents of young children in the lower SES area who asked: *"Oh that's the heat one?"* Seniors in the higher SES area summed up AQHI confusion by stating: *"Unfortunately [in] our society there are so many similar acronyms for different things depending on the field you're in."*

Sensory Cue Precedence

Moreover, participants expressed that they relied on sensory cues (i.e. feel, taste, sight) over real-time measured and reported air quality information to implement health protective behaviors, with this sensory cue precedence a barrier to AQHI adoption. Aside from respiratory health care providers, all other participants emphasized that they mainly rely on sensory cues (i.e. feel, taste, sight) to implement health protective behaviours related to air quality. The senior care provider in the lower SES area indicated: *"It's like when I open the window and I don't feel good it's not a good time to go outside."* This reliance on sensory cues was also expressed by the child care provider in the higher SES area who indicated: *"…I think it's very much personal cues…"* and the child care provider in the lower SES area who stated: *"…the staff go outside for a few minutes and they notice or they'll go on their lunch and they come back… you can't breathe outside...the air quality is not the greatest today, then we would definitely keep the children inside."*

In addition, sensory cue precedence was expressed by people with existing respiratory conditions in the lower SES area who indicated: *"If it's that hot out I'm not going out."* Seniors in the lower SES area also voiced reliance on sensory cues by stating: *"You can taste what's out there in that air."* Also seniors in the higher SES expressed that: *"You can see the haziness in the air. You are able to see in the atmosphere."* Similarly, parents of young children in the higher SES area stated: *"You just kind of go outside and you're like, yeah it feels okay out there."*

Time Constraints

An additional barrier to AQHI adoption expressed by participants includes time constraints. Aside from respiratory health care providers who visit the weather website to calibrate equipment to conduct their work, senior and child care providers indicated that their current work demands are not conducive to checking AQHI throughout the day. In addition, at risk populations also stressed the inconvenience of checking throughout the day. The senior care provider in the higher SES area indicated: *"So many things come down to just time."* Likewise, the child care provider in the higher SES area indicated: *"…personally I don't have time in here for that"* and the child care provider in the lower SES area reiterated: *"…sometimes it's hard to do that because, you know, you're rushing to get to work."* The inconvenience of checking AQHI information via the website was

expressed by people with existing respiratory conditions in the higher SES area who indicated: *"I just don't think many people want to go in and click 100 times to get to the thing…"*

4.3.3 Strategies To Increase AQHI Uptake

Professional Network Promotion

A facilitator to AQHI adoption included AQHI promotion via professional networks. Health care and service providers indicated that they rely on their existing professional networks such as upper management and public health services for guidance regarding tools to protect the health of their at risk populations from exposure to air pollution. Supportive comments with respect to engaging upper management about AQHI such that they could pass on the information to staff were provided by the senior care provider in the lower SES area who indicated: *"I think meeting all the Directors of Nursing"* in reference to increasing AQHI implementation in practice. Additional supportive comments from the senior care provider in the higher SES area included: *"I always enjoy getting things from Public Health because they're usually good."* As well, those with existing respiratory conditions in the higher SES area praised their respiratory care provider with guiding them and stated: *"I think someone like [respiratory health care provider] just telling you point blank this is your situation and this is what you have and you have to take care of it."* Acknowledgement was also expressed by parents of young children in the lower SES area who indicated: *"And I mean being at the daycare they*

would always tell us the air quality."

Health Benefit Emphasis

The other strategy to increase AQHI uptake offered by participants included emphasis on the health benefits of AQHI adoption. The senior care provider in the higher SES area stressed the need to *"…explain the benefits from it [AQHI] too…"* such that the importance of using the tool would be clear. Seniors in the lower SES area expanded on the need to emphasize the benefits of the AQHI via clear communication by stating: *"If they said what AQHI meant."* As well, the need to emphasize AQHI benefits was expressed by parents of young children in the lower SES area who suggested: "*If you tell me the importance of it and I grasp that, then I'm going to check no matter what*."

Neighbourhood Scale Focus

Participants also expressed that AQHI information reported at a neighbourhood scale as a facilitator to AQHI adoption. Participants stressed the difference in air quality experienced above (higher SES, further from IC) and below (lower SES, closer to IC) the Niagara Escarpment, with the air quality 'above' the escarpment perceived as being more favourable than that below the escarpment. The child care provider in the lower SES area described these differences in air quality by stating: *"…when they come into or closer to the city, like the downtown area they find it's more congested."* Likewise people with existing respiratory conditions in the lower SES area expressed: *"They are saying air*

quality but what about down the city and then the mountain… it's so different." These differences in air quality were stressed again by parents in the lower SES area who stated: "*There's way more pollution here [downtown below escarpment]."* Additional support for AQHI information at a neighborhood scale was expressed by the people with existing respiratory conditions in the higher SES area who reflected upon the current AQHI information and indicated: *That's unsettling because they may say it's 3 on theirs and my area might be higher…"*

Local Media Reporting

Participants expressed that local media reporting of AQHI as a strategy to increase AQHI uptake. Parents of young children in the lower SES area stated: *"…people do watch the news."* Likewise, seniors in the lower SES area articulated that *"The radio in my opinion is better…"* and people with existing respiratory conditions in the lower SES area noted that *"It should be on the first page [newspaper]."*

Wearable Device Option

Participants suggested that providing AQHI information on wearable devices could act as a strategy to increase AQHI uptake. Wearable devices reporting current AQHI information were identified as being facilitators to AQHI adoption by people with

existing respiratory conditions in the higher SES area. They noted that real-time AQHI information is critical for health protection and proposed: *"But what about some kind of a bracelet that we could wear and if the air quality gets bad our bracelet would change colour and we'd know get our[selves] in the house."*

4.4 Discussion

Since AQHI reporting in Hamilton first started during the summer of 2011, Ontario -wide reporting of AQHI has been implemented to communicate the health risks of outdoor air pollution. Therefore, adoption of the AQHI is critical to protection of population health from outdoor air pollution exposure, particularly for at risk populations and those caring for them. In this exploratory study, health care and service providers and their respective at risk populations not only expressed their level of AQHI knowledge but also provided insight into the factors influencing AQHI adoption and offered strategies that may increase AQHI uptake.

Our study found that AQHI knowledge centered on numerical reliance and health protective intent but varied with SES. This is consistent with our previous work on AQHI knowledge in Hamilton [36] which also highlighted that there was knowledge about the health protective intent of the AQHI but this knowledge varied with SES. Research points out that health literacy and numeracy (ability to use numerical health information to make appropriate decisions about health) are critical for health self-management which

would include AQHI adoption [37]. Accordingly, understanding AQHI, which is expressed on a scale from 1 to 10 is critical to health protection and perceptions of health-related risk [38]. Moreover, as other studies have found [39] including our previous work assessing AQHI knowledge in Hamilton [36], this study found a higher level of AQHI knowledge among higher SES individuals. Although increasing AQHI knowledge is critical in all at risk populations, particular attention must be given to seniors living in lower SES areas suffering from co-morbidities [40]. In the US, higher rates of limited health literacy (ability to use health information to make appropriate decisions about health) were found in those of lower SES and the elderly [41].

Increasing AQHI knowledge among the at risk populations could be achieved via AQHI promotion by their respective health care and service providers. Professional networking via social media sites for health care professionals provides an opportunity to communicate about patient issues in a protected forum [42]. Therefore, increases in AQHI knowledge could be fostered by AQHI promotion among health care and service providers via social media sites [43]. In turn, health care and service providers would be able to transfer AQHI knowledge to their respective at risk populations [12].

Not only is knowledge instrumental with respect to AQHI adoption, but so are the characteristics of the AQHI. In line with Rogers [14], because the relative advantage of the AQHI was not clear to service providers and the public, the benefits in terms of

decreasing adverse health effects due to air pollution exposure were difficult to perceive and AQHI was not adopted by the majority of participants. Therefore, improving effectiveness of AQHI messages such that they reach at risk populations and those caring for them to persuade behaviour change can be achieved by emphasizing the health benefits of the AQHI [44].

Due to geographical variability and the inability of the AQHI to capture air quality and health information in real-time at a neighbourhood scale, uncertainty in AQHI information was experienced. Consistent with our previous work [36], sensory cues (i.e. feel, see, taste) were preferred over AQHI information to guide health protective behaviour. Therefore, AQHI information reported at a neighborhood scale would assist in addressing this uncertainty which may in turn decrease the likelihood of sensory cues being used solely to guide health protective behavior in response to air pollution exposure [45]. Consequently, health care and service providers would be less inclined to implement health protective behaviors for their respective at risk populations based on their own sensory cues which may differ from that of their at risk populations. Health care and service providers' adoption of AQHI without sensory cues is critical to the protection of at risk populations and promoting health protective behaviour.

The most common reported barrier influencing AQHI adoption included time constraints. Consistent with what health care providers such as physicians [46] and nurses [47] have

reported with respect to implementing new innovations in practice, time constraints were the most commonly reported barriers to AQHI adoption by health care and service providers in our study. Likewise, time constraints were the most common barrier reported by the population with respect to engaging in health protective behaviours including physical activity [48] and vaccination [49]. By reporting AQHI information on local media (i.e. television, radio, newspaper) and providing a wearable devices option [50] at risk populations and those caring for them would have access to AQHI information all the time with little effort.

4.4.1 Limitations

Response bias would imply that health care and service providers and "at risk" populations who participated were likely to be interested in AQHI. Another limitation is that our methodology involved a time gap of over 3 years between the focus group discussions. We experienced challenges in recruitment of lower SES at risk populations with existing respiratory conditions (i.e. asthma). Consequently, our methodology involved a comparison of groups with asthma and chronic obstructive pulmonary disease (COPD) as existing respiratory conditions. This delay could have impacted the factors explored in this study; however, no new information was attained from the COPD focus group. Additionally, due to a malfunctioning recorder, one interview was not recorded and transcribed: only notes were taken.

Our study only included one health care and service provider from the lower and higher SES areas, respectively. Given our preference to recruit health care providers that were working directly with at risk populations, we did not recruit specialists such as cardiologists or respiratory physicians working in the City. Consequently, we did have a small sample of health care and service providers in our study. However, all participants including the at risk populations were asked the same questions via two different data collection methods, ensuring data triangulation. Because triangulation can be used to explore one phenomenon from different points and perspectives, it propels towards data saturation [51]. By using this approach, no new information was attained since similar responses were provided again and again [52].

4.4.2 Implications for research

The Diffusion of Innovations model was useful in explaining health care and service providers' and their respective "at risk" populations' decision to adopt the AQHI. We incorporated the determinants of health framework by examining health care and service providers' (organization) and their at risk populations' (community) adoption of the AQHI in lower and higher SES areas. Further research should bridge AQHI adoption at the individual, organization and community level with a "determinants of health" lens in order to develop a comprehensive approach.

4.4.3 Implications for practice

Intervention strategies to increase AQHI knowledge and encourage adoption at risk populations in lower SES areas should be considered as upstream public health measures designed to offset potentially significant downstream costs.

4.5 Conclusions

Our exploratory qualitative study highlighted that AQHI knowledge, AQHI characteristics and perception of air quality and health were critical to AQHI adoption. By increasing AQHI knowledge, emphasizing AQHI relevance, and reporting AQHI information at a neighbourhood scale via local media sources and wearable devices, increases in AQHI uptake can be achieved while accounting for SES differences.

Declarations

Ethics approval and consent to participate

This research received ethics approval from McMaster University Research Ethics Board. Certificate of Ethics Clearance to Involve Human Participants in Research Project Number: 2012 109.

Availability of data and materials

Signed confidentiality agreements prevent us from sharing the data.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

All authors were involved in interpretation of the results and revision and approval of the submitted version. Additionally, SR contributed to conception and design of the study and acquisition of data and analysis. BN supervised the study. SR and BN contributed to the interpretation of data. SR drafted the manuscript, and BN revised it critically for important intellectual content.

Acknowledgements

We acknowledge support of the publication fee by the City of Hamilton Public Health Services.

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Table 1 Air Quality Health (AQHI) Messages According to Health Risk Categories [10]

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	**General Population**
Low	**1 - 3**	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	**4 - 6**	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	**7 - 10**	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	**Above 10**	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation

*People with heart or breathing problems are at greater risk.

Table 2 Interview Participant Characteristics

	N=6 (%)
Gender	
Male	1 (17.0%)
Female	5 (83.0%)
Employee Status	
ECE, Supervisor Child Care Facility	2 (33.3%)
RN, Supervisor Senior Retirement Home	2 (33.3%)
RN, Certified Respiratory Educator	2 (33.3%)
At Risk Population Served	
Young Children	2 (33.3%)
Senior (≥65 years)	2 (33.3%)
Existing Respiratory Condition	2 (33.3%)
SES Area Served/Location	
Higher/Above Niagara Escarpment	3 (50.0%)
Lower/Below Niagara Escarpment	3 (50.0%)

Table 3 Focus Group Participant Characteristics

	N=44 (%)
Gender	
Male	10 (23%)
Female	34 (77%)
Age	
18-24	5 (11%)
25-34	8 (18%)
35-44	3 (7%)
45-54	2 (4%)
55-64	6 (14%)
65-74	13 (30%)
75 and over	7 (16%)
Education	
Elementary School	1 (2%)
High School	19 (43%)
College	16 (36%)
University	8 (18%)
At Risk Group Represented	
Young Children	16 (36%)
Older Adults (≥65 years)	13 (30%)
Existing Respiratory Condition	15 (34%)

SES Area of Residence/Location	
Higher/Above Niagara Escarpment	21 (48%)
Lower/Below Niagara Escarpment	23 (52%)

Table 4 Themes Corresponding to AQHI Knowledge, Factors Influencing AQHI and Strategies Increasing AQHI Uptake

Category	Theme
Knowledge	Numerical Reliance
	Health Protective Intent
	SES Differences
Factors Influencing AQHI Adoption	Relevance
	Index Confusion
	Sensory Cue Precedence
	Time Constraints
Strategies Increasing Uptake	Professional Network Promotion
	Health Benefit Emphasis
	Neighborhood Scale Focus
	Local Media Reporting
	Wearable Device Option

Figure 1 AQHI Adoption Process (Adapted from Rogers, [14])

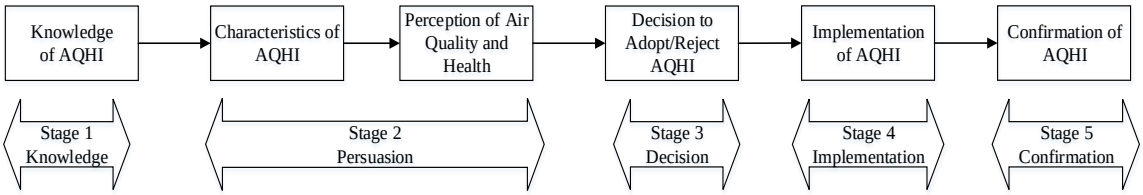
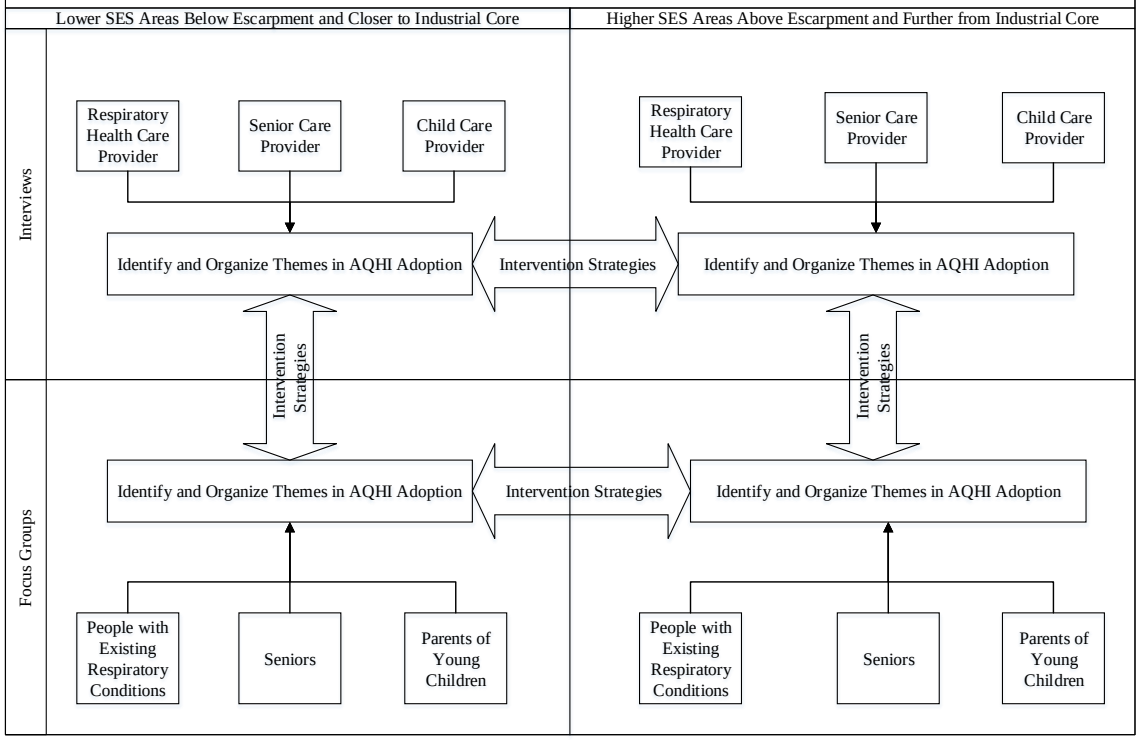


Figure2 Data Collection Method and Analysis Procedures



Chapter 5: Air Quality and Health Education to Increase Knowledge and Encourage Health Protective Behavior Among Older Adults in Hamilton, Canada

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Reference:

Radisic, S. & Newbold, K.B. (2015). Air Quality and Health Education to Increase Knowledge and Encourage Health Protective Behavior Among Older Adults in Hamilton, Canada. *Environmental Health Review*, 58(4): 87-94.

ABSTRACT

Air pollution exposure is detrimental to population health and particularly to older adults (≥ 65years of age) who are considered part of the "at risk" population. The Air Quality Health Index (AQHI) provides air quality and health information such that the public can implement health protective behavior and decrease exposure to outdoor air pollution. The AQHI education session for older adults aims to: 1) increase knowledge and 2) encourage use of the AQHI. An AQHI education session was delivered face-to-face to older adults living independently in Hamilton, Canada. A pre- and post-test questionnaire with both quantitative and qualitative questions was administered to measure knowledge and intention to use AQHI. A total of 62 participants attended the education session and completed the pre- and post- test questionnaire. Results of a paired *t* test indicated a statistically significant difference in pre- and post-test knowledge ($p<0.05$). After the education session, 82% of participants indicated intention to use AQHI. The benefit of using AQHI included health protection while the most relevant barrier was the inability to self-identify as belonging to the elderly "at risk" population. An AQHI education session was effective in increasing AQHI knowledge and encouraging use of the AQHI. Consideration must be given to replacing the current terminology "elderly" with the use of chronological age (≥65 years) to describe the "at risk" population and foster greater ability to self-identify and use AQHI. Extra attention must be given to engage older adults living in lower socioeconomic (SES) areas to address health disparities.

KEY WORDS: air quality, environmental health; health protective behavior; behavioral theories; health promotion; health disparities

5.1 INTRODUCTION

Public health promotion and prevention efforts aim to improve quality of life and reduce health disparities in the population (Glanz and Bishop, 2010). Through evaluation of a health promotion intervention, information about how a program is working and whether it has had its intended effect can be determined such that changes can be made to improve the program and findings can be used to guide other programs (Weinstein et al., 2008).

The World Health Organization (WHO) estimated that 3.7 million people around the world died in 2012 as a result of outdoor air pollution exposure (WHO, 2014). In Canada, between 2008 and 2031, air pollution attributed deaths are predicted to rise 83% of which most will be older adults (Canadian Medical Association, 2008). Although exposure to air pollution has been associated with adverse respiratory and cardiovascular health effects for the population as a whole (Zanobetti et al. 2009; Pope et al. 2002; Dockery et al. 1993), older adults (≥65years of age) are considered to be more sensitive to air pollution exposure than the general population (Goldberg et al., 2000). The population is getting older on a global scale (WHO, 2014). It is expected that the number of people over the age of 60 will double from 11% in 2000 to 22% in 2050 (WHO, 2014). In 2013, 15.3% of the population in Canada was ≥65 years of age and by 2030 this group is estimated to increase between 22% and 24% (Statistics Canada, 2014). Research has found that the prevalence of chronic conditions (i.e. respiratory and/or cardiovascular

conditions) increases with age (Turcotte and Schellenberg, 2006). Findings indicate that over 90% of older adults suffer from at least one chronic condition while over 70% suffer from at least two chronic conditions (Anderson, 2010). Coexisting heart (i.e. heart failure) and respiratory conditions (i.e. Chronic Obstructive Pulmonary Disease Older (COPD)) are commonly reported in older adults (Rutten et al., 2006). In 2012, older adults accounted for 45% of health care costs in Canada (Canadian Institute for Health Informatics, 2014). In the Organization for Economic Co-operation and Development (OECD) countries the economic costs of air pollution were estimated to have reached 1.7 trillion dollars (US) in 2010 (OECD, 2014).

In Canada, the Air Quality Health Index (AQHI) is a comparatively easy to understand 10-point scale (low risk 1-3, medium risk 4-6, high risk 7-10, very high risk greater than 10) which provides air quality and health information such that the public can implement health protective behaviors (reducing and/or rescheduling outdoor activities during periods of poor air quality) and decrease exposure to outdoor air pollution (Environment Canada, 2015). The AQHI recognizes that the elderly, along with young children and those with pre-existing respiratory and/or cardiovascular conditions are more sensitive to air pollution in its Health Messages and refers to this group as the "at risk" population (Table 1) (Environment Canada, 2015).

Because older adults are more susceptible to the adverse effects of air pollution, suffer from coexisting chronic conditions (i.e. cardiovascular and respiratory), account for substantial health care costs and as a population are expected to increase substantially, intervention strategies encouraging this "at risk" population to adopt the AQHI must be

applied. With effective AQHI education, older adults can make appropriate decisions about using the AQHI to protect their health. Therefore, an AQHI education session to increase knowledge and encourage use among older adults was implemented and evaluated to determine effectiveness and provide insight about improvements.

5.2 METHODS

5.2.1 Setting

The education sessions were held in the City of Hamilton, Ontario. Hamilton is an industrial city consisting of a population of over 519, 000 people, with 84.1% speaking English in the home (Statistics Canada, 2012). Situated at the western end of Lake Ontario, the City of Hamilton consists of five relatively high socioeconomic status (SES) suburban areas and a low SES inner city (DeLuca et al., 2012). Several studies have identified that there are spatial variations in air pollution concentrations in the City of Hamilton (Wallace et al., 2010). Factors contributing to air pollution variation include (Wallace et al., 2010): traffic, industry, meteorological conditions, and the geographical upper and lower city divide by the Niagara Escarpment, potentially entrapping pollutants.

5.2.2 Participants

Participants consisted of a convenience sample of individuals living independently in affordable seniors' buildings with the ability to read, complete the pre- and post-test questionnaire and participate in the education session.

Seniors' buildings are located in both urban and suburban areas of Hamilton. Participants were recruited with the assistance of the recreation coordinator for the

seniors' programs in the City of Hamilton and the community relations workers for each building. Recruitment posters were posted in nine seniors' buildings throughout the city. Interested older adults signed up for the education sessions with the community relations worker at each corresponding site.

5.2.3 Education Session Development

Recommendations for communicating with older adults (Clark, 2011) along with health behavior theory were integrated in both the slide presentation (available from the author) and the pre-and post-test questionnaire (Table 2) developed for the AQHI education session. Therefore, the presented AQHI information was easy to see, hear and understand (Clark, 2011). In addition, the education sessions were delivered face-to-face by the first author at seniors' buildings (Clark, 2011). Moreover, the Precaution Adoption Process Model (PAPM) (Weinstein et al., 2008) provided the theoretical framework for understanding AQHI adoption by older adults. This health behavior model was selected because it is stage based and takes into consideration the steps and mental states at each stage required for an adoption of a new health behaviour to take place. Moreover, PAPM takes into consideration the qualitative explanations for movement from one stage to the next and has been used previously to promote other public health programs such as physical activity to older adults (Brawley et al., 2003). The model postulates that there are seven stages by which the group of older adults can be moved from being unaware (Stage 1) to aware but unengaged (Stage 2) to the decision-making stage (Stage 3) where

they can decide not to act (Stage 4) or act (Stage 5) at which time they act (Stage 6) and finally move to maintaining the behaviour (Stage 7).

Figure 1 illustrates the stages of the PAPM for AQHI adoption. By increasing knowledge about the AQHI, the education session can move older adults from being unaware (Stage 1) and unengaged (Stage 2) to decision-making (Stage 3) where they can decide to (or not) use the AQHI. The decision to use or not use AQHI will be weighed on benefits and barriers associated with the behaviour (Weinstein et al. 2008). Therefore the education session focused on the benefits of AQHI in terms of reducing the risk of adverse health effects from air pollution exposure. In addition, the qualitative questions in the pre- and post-test questionnaire addressed the benefits and barriers by asking participants to explain why they did (didn't) use the AQHI, why they intended (or didn't) to use AQHI and what further resources (i.e. programs, services) would help them use the AQHI. In an effort to positively reinforce the behaviour of initiating and completing the pre- and post-test questionnaire, relatively simple questions were placed at the beginning and end of the questionnaire.

5.2.4 Education Session Description

This research received ethics approval from the McMaster University Research Ethics Board and informed consent from participants prior to conducting the study. The education session on the AQHI was delivered by the same public health professional at each of the seniors' buildings. Each education session was approximately one hour in

length where participants were asked to: 1) complete a pre-test questionnaire, 2) listen to and watch a 30 minute slide presentation on the AQHI and 3) complete a post-test questionnaire. Participants were encouraged to ask questions throughout the session. AQHI promotional materials (i.e. water bottles, pedometers, pens, etc.) were provided as compensation for participating.

5.3 RESULTS

A total of six education sessions were held from June 2014 to October 2014 in community rooms at seniors' buildings from across the City of Hamilton. A count of individuals present was taken at the beginning of each session. A total of 68 participants attended the educational presentations and 62 completed the pre- and post- surveys. Descriptive statistics (Table 3) and paired *t* tests of pre- and post- participant responses (Table 4) were performed with the use of Microsoft Excel.

The majority (92%) of participants were female and only 8% were male. Nine participants were aged 55-64. Just under half (45%) were between 65-74 years of age, with the balance (39%) 75 years of age and older. Participants living in the lower, inner city made up 36% of the sample, while participants living above the escarpment made up 40% and 16% lived in the suburban area of Hamilton. With respect to belonging to the "at risk" population, 90% of participants were either elderly (≥65years of age) and/or had a pre-existing respiratory and/or cardiovascular condition and therefore would be considered "at risk".

5.3.1 AQHI Knowledge Pre Education Session

The study found that before the education session, most participants were aware that the AQHI was on a ten point scale. Additionally, most participants knew that an AQHI of 7 suggests the risk of developing health symptoms is higher than usual. Moreover, the majority of participants were also able to identify who was "at risk" and that AQHI Health Messages are available for both the "at risk" and general populations (Table 4). Less than half (42.6%) of participants knew what pollutants are included in the AQHI (nitrogen dioxide ($NO_{2)}$, Ozone (O_3) and particulate matter ($PM_{2.5}$)). While, more than half (58.1 %) of the participants knew that AQHI Health Messages did not include information about avoiding sun exposure. Likewise, the same percentage (58.1%) knew current and forecast AQHI information was available for today, tonight and tomorrow. Again, more than half (65.1%) knew where to find AQHI numbers and understood AQHI could be used to plan outdoor activities (69.4%).

5.3.2 AQHI Knowledge Post Education Session

Based on the post-intervention test, there were improvements in all nine questions following the AQHI education session (Table 4). The question most likely to be answered incorrectly before the education session was the question requiring participants to identify the pollutants (NO_2, O_3, $PM_{2.5}$) included in the AQHI; however, 84.3% of participants in the post education session were able to answer that question correctly.

Moreover, post education session 73.8% of participants understood what information AQHI Health Messages communicate and 85.1% understood how the AQHI can be used to help plan outdoor activities.

5.3.3 AQHI Use Pre Education Session

Before the education session only 32% indicated that they use the AQHI. Participants indicated the benefits of using AQHI included health protection since they had pre-existing respiratory and/or cardiovascular conditions. Participants indicated that the benefits of using AQHI helped with "using my puffers" "due to breathing problems", "respiratory condition" and notice that on "good days it is easier to breath". Not only did they indicate that being "at risk" as a reason for using AQHI but they also indicated that they used AQHI because they wanted to plan "outdoor activity with heart condition".

With respect to the barriers to using AQHI, participants indicated lack of knowledge as a reason for not using the AQHI. Participants noted that they "have not been introduced to this discussion before" and that "workshops and presentations" would help them use the AQHI. Moreover, participants suggested that because "I do not have trouble breathing" and not believing that they were "at risk" since "no problem breathing outdoors – so far", they did not need to use the AQHI.

5.3.4 Intention to Use AQHI Post Education Session

After the education session, 82% of all participants indicated that they intended to use the AQHI. The intention to use AQHI post education session was higher at 85% for participants 65 years and over. One of the reasons participants indicated that they intended to use AQHI included the education session and the knowledge gained from the session. Participants explained that the "Education Session got me interested!!", "Now I understand it better [and] it makes more sense to use it" and "I can see how benificial it is". Participants explained that "workshops", "Presentations like this are great…" and "The lady that came was very informated" which will help them use AQHI.

As participants indicated pre education session, reasons they intended to use AQHI post education session included the benefits of health protection. Participants indicated that they intended to use the AQHI because it will "give me the info I need" for "better health" and "to protect heart". Moreover as with the pre education session, participants indicated that they intended to use the AQHI because it will help plan outdoor activity by stating "…I want to go out plan my day" and "to pay more attention to the quality of the air for walking". Also, the fact that participants indicated that they intended to use the AQHI "to help others who is not to familiar with risks" suggests that knowledge transfer and taking care of others is a reason for using AQHI.

5.3.5 Self-Identifying with "At Risk" Population

The majority of participants (84%) were 65 years of age and over; however, only 46% of these individuals indicated that they belonged to the "at risk" population before the education session. After the education session, 57% self-identified as belonging to the "at risk" population. Even after the education session, 46% of those 65 years and over attributed belonging to the "at risk" population because of pre-existing respiratory and/or cardiovascular conditions. Further, only 19% of those individuals indicated that they were "at risk" because they were elderly.

5.4 DISCUSSION

Knowledge is the first step in the adoption process, but it is not the only step required to adopt the AQHI. Even after participants gain knowledge about AQHI there is still decision making (Stage 3) that needs to take place where benefits and barriers are weighed in order to determine whether they will act (Stage 5) or not (Stage 4). Although, most participants were able to identify who belongs to the "at risk" population (young children, elderly and those with pre-existing respiratory and/or cardiovascular conditions) they failed to self-identify as being "at risk". Findings from this study suggest that the barrier most relevant (Weinstein et al., 2008) to this population is the inability to self-identify as "elderly" and therefore "at risk".

Older adults are a heterogeneous group so there is no one definition of "elderly". Often there is a discrepancy between how old a person feels and his/her actual age; the age people perceive themselves to be is referred to as a subjective age (Kotter-Gruhn and

Hess, 2012). There has been much written about the stigma associated with aging in today's youth-driven society (Schoemann and Branscombe, 2011). Ageism has been experienced in the workplace (McCann and Giles, 2002), and in dealing with health care professionals (Greene et al., 1986). It has been suggested that because they are exposed to negative concepts of aging, older adults internalize negative stereotypes of what it means to be "elderly" (Levy, 2003). Therefore older adults are reluctant to consider themselves as being "old" or "elderly" (Hurd, 1999; Linn and Hunter 1979). This reluctance to consider oneself as "elderly" is referred to as disidentification; it is a coping strategy used by individuals who choose not to identify with the stigma of being "old" (Weiss and Freund, 2012; Weiss and Lang, 2012; Steele, 1997).

The definition of being "at risk" clearly states that it includes those who are "elderly" which may deter some individuals from self-identifying with being "at risk" since they do not consider themselves as "elderly". This study suggests that older adults disidentify with the term "elderly" and therefore are unable to identify with being "at risk". This idea is supported by the fact that older adults were able to self-identify as being "at risk" if they have a pre-existing respiratory and/or cardiovascular condition. A better approach may be to redefine "at risk" with a chronological age of 65 years or over since research suggests that older adults acknowledge their chronological age (Linn and Hunter, 1979). Therefore, the terminology "elderly" being used to describe individuals belonging to the "at risk" population may be a barrier to self-identifying and adopting the AQHI for older adults.

Finally, although participants from both higher and lower SES areas participated in the AQHI education sessions, education sessions in the lower SES area of the city had to be rescheduled at least once and sometimes two or three times before participants were engaged and agreed to attend. Some studies have found that public health interventions appear to have inadvertently increased health inequalities (Frohlich and Potvin, 2008). Therefore extra effort was taken to work with the recreation coordinator and community relations workers to provide outreach in lower SES seniors' buildings and promote participation in the AQHI education session.

5.4.1 Limitations

Although convenience sampling is fast and inexpensive it suffers from sampling bias and may not be representative of the entire population. Therefore, there is a limitation in terms of generalizability; however, transferability is the intention of this research with the hope that findings from this research can be applied to settings with similar populations and characteristics. Furthermore, the high response rate from females and low response rate from males may be contributing to self-selection sampling and impacting results. However, because older women are more likely to live longer, the number of older women in the population is greater than the number of older men in nearly every part of the world (United Nations, 2013).

5.4.2 Implications for Practice

There are important implications from this research for public health practitioners. First, as Glanz et al. (2008) emphasize, public health professionals need to be will informed about both the health behavior and the context in which the health behavior is taking place. Understanding health protective behavior in response to poor air quality within the different SES areas of the City of Hamilton was important in terms of addressing potential health disparities within this population. Extra efforts were taken to engage older adults living in lower SES areas of the City such they had the same opportunity to learn about AQHI and make decisions about using the tool as older adults living in higher SES areas had. Second, public health professionals must tailor health messages such that the information presented is made relevant to the target population (Kreuter et al., 2003). Using the term "elderly" without the use of the chronological age of ≥65 years to describe the "at risk" population was not of any relevance to the majority of participants in this study since they failed to self-identify. Therefore, consideration must be given to the health behavior, the context of the health behavior along with the tailoring of health messages to reach the target population.

5.5 CONCLUSION

This public health intervention aimed to increase knowledge and encourage use of the AQHI while at the same time work to reduce health disparities among older adults in the City of Hamilton. Findings suggest that the intervention was effective in increasing knowledge and encouraging use of the AQHI. Also, the evaluation provided insight

regarding changing the current terminology “elderly” and replacing it with chronological age (≥65 years of age) such that self-identification with the “at risk” population and adoption of the AQHI are fostered. It is anticipated that these findings may be useful in planning other public health programs designed to improve the health of older adults in the population.

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Table 1. Air Quality Health (AQHI) Messages

Source: Environment Canada, 2014

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	**General Population**
Low	**1 - 3**	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	**4 - 6**	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	**7 - 10**	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	**Above 10**	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation

*People with heart or breathing problems are at greater risk.

Table 2. Pre-test and Post-test Questionnaire

1) The Air Quality Health Index (AQHI) measures **air quality** in relation to **health** on a scale from 1 to 10.

   True ☐ False ☐

2) Which of the following is used to calculate the Air Quality Health Index (AQHI)? (Check as many as apply.)

   a. Nitrogen Dioxide ☐
   b. Ozone ☐
   c. Particulate Matter ☐
   d. Odour ☐
   e. Pollen ☐
   f. Humidity ☐
   g. Heat ☐

3) An Air Quality Health Index (AQHI) reading of 7 means that the **risk** of developing health symptoms is **higher** than usual.

   True ☐ False ☐

4) Which of the following statements about Air Quality Health Index (AQHI) Health Messages are true (Check all that apply):

   a. advise how you can protect your health from the negative effects of air pollution ☐
   b. different for the "at risk" population and the general population ☐
   c. are available for different levels of health risk (i.e. Low Risk, Moderate Risk, High Risk, and Very High Risk) ☐
   d. advise you to avoid sun exposure ☐

5) The Air Quality Health Index (AQHI) helps you plan your outdoor activity by showing the current value and the maximum forecast for:
   (Check all that apply.)

   a. today ☐
   b. tonight ☐
   c. tomorrow ☐

6) The Air Quality Health Index (AQHI) is a tool that helps you plan and decide when to: (Check all that apply.)

   a. be active outdoors ☐
   b. reduce your outdoor activity ☐

c. reschedule your outdoor activity ☐
d. apply sunscreen ☐

7) Where could you check for the Air Quality Health Index (AQHI)? (Check all that apply.)

a. Television Weather Network ☐
b. Website ☐
c. Environment Canada Air Quality Health Index (AQHI) Telephone Number ☐
d. Other ☐ Please Specify _____

8) People who may be more sensitive to air pollution include: (Check all that apply.)

a. Young children ☐
b. Elderly ☐
c. People with pre-existing respiratory (breathing) conditions ☐
d. People with pre-existing cardiovascular (heart) conditions ☐

9) Are you part of any of the "at risk" populations noted above?

Yes ☐ No ☐ Not Sure ☐

10) If Yes, please indicate which of the "at risk" populations:_____

11) The Air Quality Health Index (AQHI) communicates Health Messages **ONLY** for the "at risk" population.

True ☐ False ☐

12) Do you currently **use** the Air Quality Health Index (AQHI)?

Yes ☐ No ☐ Not Sure ☐

Tell us **Why?**

13) Do you **plan/intend** to **use** the Air Quality Health Index (AQHI)?

Yes ☐ No ☐ Not Sure ☐

Tell us **Why?**

14) What information, programs or services would help you use the Air Quality Health Index (AQHI)?

Table 3. Sample Characteristics

Characteristic	N=62	%
Gender		
Male	5	8
Female	57	92
Missing	0	0
Age		
55-64	9	14
65-74	28	45
75+	24	39
Missing	1	2
Area of Residence		
Lower City	22	36
Mountain	25	40
Suburban Area	10	16
Missing	5	8
“At Risk” Population		
Elderly (65 years of age and older)	52	84
Pre-existing respiratory condition	12	19
Pre-existing cardiovascular condition	6	10
Pre-existing respiratory + cardiovascular condition	7	11

Missing	1	2
Yes (65 years of age or older, pre-existing respiratory and/or cardiovascular condition)	56	90
No	5	8
Missing	1	2

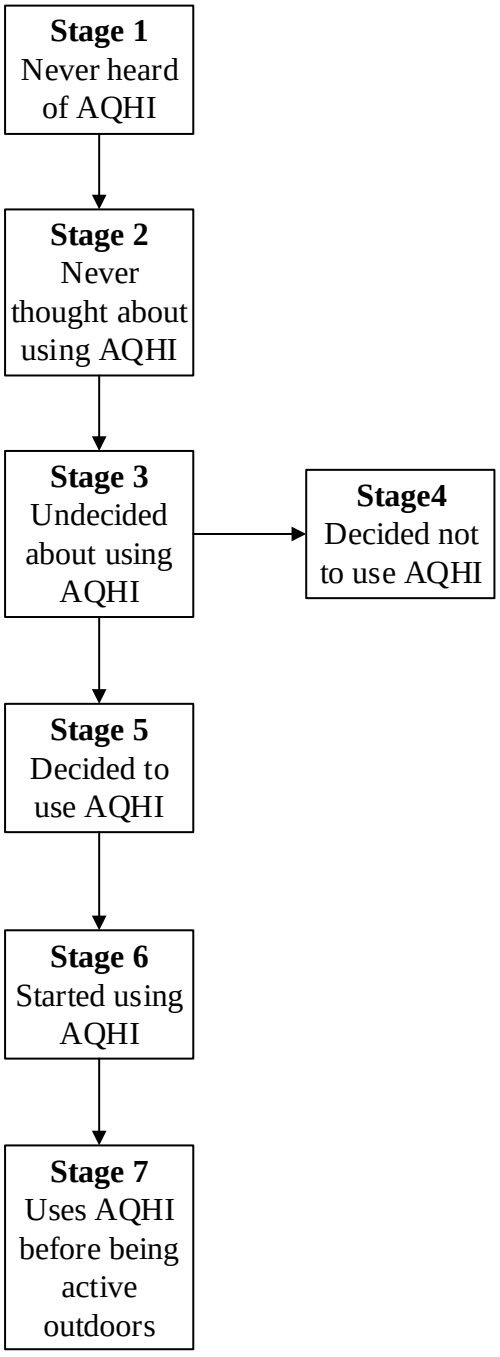
Table 4. Air Quality Health Index (AQHI) Knowledge of 62 participants Before and After Education Session

Question	Pre-test %	Post-test %	Difference	Improvement %†
1. AQHI is a scale from 1-10	85.5	95.2	9.7	66.9
2. AQHI: Nitrogen Dioxide, Ozone, Particulate Matter	42.6	84.3	41.7**	72.6
3. AQHI 7: High Risk	82.3	95.2	12.9*	72.9
4. AQHI Health Messages:≠avoid sun exposure	58.1	73.8	15.7**	37.5
5. AQHI: today, tonight and tomorrow	58.1	81.7	23.6**	56.3
6. AQHI tool to help decide when to ≠apply sunscreen	69.4	85.1	15.7**	51.3
7. Check AQHI: weather network, website, dedicated telephone lines	65.1	80.6	15.5**	44.4
8. At risk population: young children, elderly, pre-existing respiratory and/or cardiovascular conditions	82.7	90.7	8**	46.2
9. AQHI Health Messages for "at risk" and general population	72.6	75.8	3.2	11.7

*Paired *t* test $p<0.05$, **Paired *t* test $p<0.001$, †Percent improvement calculated as (change in percent right/pre-test percent wrong)

Figure 1. Precaution Adoption Process Model for AQHI Adoption

Source: Adapted from Weinstein et al. (2008)



Chapter 6: Conclusion

The general theme for this dissertation has centred on an understanding of AQHI adoption in the City of Hamilton while accounting for socioeconomic status (SES) in order to facilitate AQHI uptake by the public with particular focus on "at risk" populations (i.e. young children, seniors, those with pre-existing respiratory and/or cardiovascular conditions). Our study is unique since it approaches AQHI adoption consistent with the ecological model and an equity lens. We looked at AQHI adoption at the individual, organizational and community levels. Our study area for this dissertation is Hamilton, Ontario, Canada. Our work bridges theory, research and practice to provide a comprehensive explanation to AQHI adoption at different levels of influence (i.e. individual, organizational, community) in the City of Hamilton. We draw on health behaviour theory and the ecological model, previous research done in Hamilton examining air pollution and health, and apply an equity lens to develop an intervention strategy that does not further increase health disparities. The findings from this dissertation contribute to an understanding of why AQHI is or is not being adopted and suggests potential intervention strategies to increase its uptake. The major findings and contributions from this dissertation are presented below.

6.1 Major Findings and Contributions

At the individual level, we found that demographics including gender, age, education and area of residence, knowledge/understanding and individual risk perceptions pertaining to neighbourhood air effects on health were significant predictors of AQHI

adoption. Moreover, we found that the perceived benefits of AQHI adoption included protection of health for self and those cared for via familial and/or occupational duties. We also identified that the perceived barriers of AQHI adoption included lack of knowledge about where to check and lack of time required to check and follow AQHI health messages. Also, self-efficacy was uncovered as a factor influencing AQHI adoption. Accordingly, in this chapter, it is suggested that increases in AQHI adoption could be achieved via increasing AQHI knowledge among low SES females, communicating the benefits of AQHI adoption to "at risk" populations and implementing supports for males to follow AQHI health messages.

Additionally, at the organizational and community levels, we found that with respect to health care and service providers and their respective "at risk" populations, AQHI knowledge, AQHI characteristics and perceptions of air quality and health influenced AQHI adoption. Furthermore, AQHI knowledge centred on numerical reliance and health protective intent but varied with SES. We identified that more emphasis on AQHI relevance with respect to health benefits was required to stress relative advantage over other indices and reduce index confusion. Findings suggested that AQHI reporting at a neighborhood scale addressed geographic variability and uncertainty in perceived versus measured air quality impacting health. Participants predominantly expressed that they relied on sensory cues (i.e. feel, see, taste) to determine when to implement health protective behaviors. As in chapter 3, time constraints were identified as barriers to AQHI adoption. However, local media reporting and wearable devices were identified as facilitators to AQHI adoption. Accordingly, in

this chapter, it is suggested that increases in AQHI adoption could be achieved via increasing AQHI knowledge, emphasizing AQHI relevance and reporting AQHI information at a neighborhood scale via local media sources and wearable devices will facilitate AQHI adoption while accounting for SES differences.

Thus, our findings suggested that an intervention strategy to increase AQHI adoption should start with increasing AQHI knowledge among "at risk" populations in lower SES areas; respectively health behaviour theory stresses that knowledge is the first step to behaviour change (Glanz, 2008). Because our previous findings not only identified that AQHI knowledge varied with SES but it also identified seniors (≥65 years) as the "at risk" population with the lowest level of AQHI knowledge, we focused our AQHI education intervention on seniors living independently in affordable housing in Hamilton. Accordingly, because our previous findings suggested that there was a need to communicate the relevance and benefits of AQHI to "at risk" populations, throughout the education session, we were able to emphasize the benefits and importance of the AQHI, thus encouraging AQHI adoption. Additionally, because the majority of participants in our intervention study were female, we were able to address the finding suggesting targeting females in lower SES areas. Our intervention appears to be promising in the sense that the results of a paired *t* test indicate a statistically significant difference in pre- and post-test knowledge ($p<0.05$) and an intention to use AQHI post education session of 82% of participants. Although we acknowledge that intention (the motivational decision to take action), to change behavior does not necessarily result in action consistent with the intention (Rhodes and de Bruijn, 2013), most theories from behavioural sciences

including the transtheoretical model maintain that intention is the proximal precursor to behavioural change (Nigg et al., 2011). Further research on the link between 'intention' and 'action' relative to the adoption of AQHI is warranted. Furthermore, the study did suggest that consideration must be given to replacing the current terminology "elderly" with the use of chronological age (≥65 years) to describe the "at risk" population and foster greater ability to self-identify and use AQHI.

Contributions from our work support a comprehensive approach to AQHI adoption and recommend focusing on:

1. increasing AQHI knowledge among low SES females;
2. communicating the benefits and relevance of AQHI adoption to "at risk" populations;
3. implementing supports for males to follow AQHI health messages;
4. providing AQHI information at a neighborhood scale via local media sources and wearable devices;
5. replacing the current terminology "elderly" with the use of chronological age (≥65 years) to describe the "at risk" population and foster greater ability to self-identify; and
6. engaging older adults living in lower socioeconomic (SES) areas to address health disparities.

6.2 Limitations

There are a number of limitations to the current study. First, we used convenience sampling in Phases I and IV. Although convenience sampling is fast and inexpensive, it suffers from sampling bias and may not be representative of the entire population. Therefore, there is a limitation in terms of generalizability. However, transferability is the intention of this research with the hope that findings from this research can be applied to settings with similar populations and characteristics. Moreover, the Phase I convenience sample was fairly representative with respect to distribution of age, income, education and population according to city divisions (Statistics Canada, 2013; Statistics Canada, 2012), over representation of females and under representation in higher SES suburban areas may have contributed to self-selection sampling which may have impacted results.

Second, as with all studies using surveys, recall and response bias may be impacting the results. Because older women are more likely to live longer and the number of older women in the population is greater than the number of older men in nearly every part of the world (United Nations, 2013) may explain the high response rate from females and low response rate from males in Phase IV.

Third, the study only included one health care and service provider from the lower and higher SES areas, respectively. Given our preference to recruit health care providers that were working directly with at risk populations, we did not recruit specialists such as cardiologists or respiratory physicians working in the City. Consequently, we did have a small sample of health care and service providers in our study. However, all participants

including the at risk populations were asked the same questions via two different data collection methods, ensuring data triangulation (Denzin, 2009; Guest et al. 2006).

Fourth, Phase IV was initiated before completing the last focus group in Phase III. The data analysis from Phase I, II and III clearly showed that seniors (≥ 65 years) as an "at risk" population were the group who identified lacking AQHI knowledge on the whole. Given this finding, the author (as a public health professional) wanted to ensure that obligations consistent with her profession's code of ethics (Canadian Institute of Public Health Inspectors) were fulfilled. In essence that she was: "…obliged to…protect the public's health." Moreover, that she was: "dedicated in the care and commitment to the public." For that reason, the author believed it was her professional duty to provide the intervention in a timely manner.

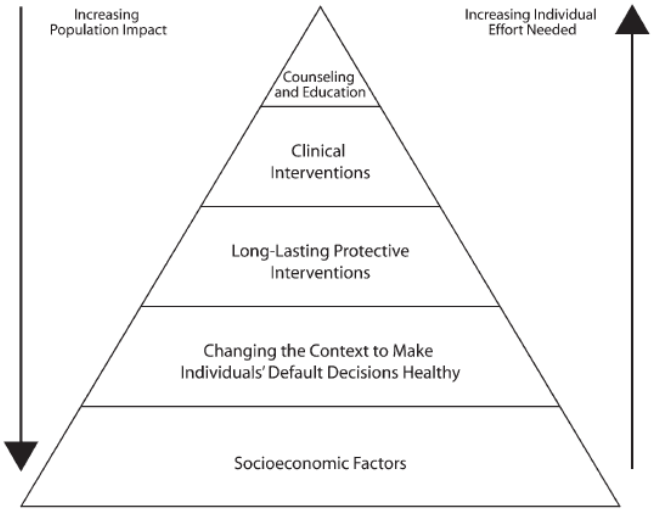
6.3 Public Health Implications

With the AQHI being reported province-wide in Ontario, municipalities will work to promote the AQHI as a means of protecting the health of their population from exposure to air pollution. Public health promotion and prevention efforts aim to improve quality of life and reduce health disparities in the population (Glanz and Bishop, 2010). In December 2015, the Ontario Ministry of Health and Long-Term Care released a discussion paper entitled " Patients First: A Proposal to Strengthen Patient-Centred Health Care in Ontario". The discussion paper acknowledges health disparities in our communities and recognizes that public health has expertise pertaining to health equity,

population health and social determinants of health. Accordingly, the discussion paper proposes that there ought to be: "stronger links between public health and other health services". By accounting for the organizational level and linking health care providers with the AQHI as a public health initiative, this dissertation aligns with the proposal in the "Patients First" discussion paper.

Furthermore, this dissertation embraces that there are different kinds of population health interventions, with some having greater impact on a population scale (those towards the bottom of the pyramid) while others are more focused on an individual scale (those towards the top of the pyramid) as shown in Figure 1 (Freiden, 2010).

Figure 1. Health Impact Pyramid (Source: Frieden, 2010)



Moreover, Frieden (2010) emphasizes that comprehensive public health initiatives aim to incorporate strategies at each of the 5 tiers within the pyramid such that the

combined effect from each tier can be maximized upon to increase the chances of sustained behaviour change.

Although our AQHI education intervention is found towards the top of the health impact pyramid (Frieden, 2010) and would suggest a focus on individual impact, our research in its entirety suggests that by increasing AQHI knowledge, communicating AQHI relevance and benefits and reporting AQHI at a neighbourhood scale, increases in population impact are possible. For example, if AQHI mass media campaigns are done effectively such that "at risk" populations self-identify, understand AQHI relevance and benefits, and trust reported AQHI information provided at a neighbourhood scale, this could change the context by altering the social norms related to outdoor physical activity during periods when AQHI levels may cause adverse health effects. Likewise, incorporation of AQHI education between health care and service providers and their respective "at risk" populations could help with behaviour change. It is recommended that in addition to the educational intervention, clinical interventions along with changing the context, as described above, be incorporated to maximize the combined effect from each intervention.

Furthermore, as we strive to implement interventions that reduce air pollution and have increasing population level impact, we need to consider the built environment which has been defined as "our physical surroundings and includes the buildings, parks, schools, road systems and other infrastructure that we encounter in our daily lives" (Health Canada, 2002). Policies that address the location of our schools, houses and parks such

that they are not within close proximity to sources of air pollution (Roorda-Knape et al., 1998) and those that support green space and trees to filter and absorb air pollution (Bowker et al., 2007) are critical to protecting the population from exposure to air pollution and adverse health effect. Although these public policies are situated "outside the formal health sector, they have an impact on health" and are referred to as healthy public policy. Through the promotion of active transportation and anti-idling by-laws, reductions in traffic-related air pollution (TRAP) can be supported (National Collaborating Centre for Healthy Public Policy, 2007). Additionally, collaboration between public health and land use planning is imperative when aiming to decrease air pollution exposure (Harris et al., 2016). These policy efforts are critical interventions that aim to address the population level impacts of air pollution.

Our results have public health importance since implementation of these intervention strategies could lead to increases in AQHI adoption and decreases in adverse health effect in the population, particularly among the "at risk" population; this could also alleviate burden and costs to the health care system. Finally, air pollution reduction interventions that have population level impacts will require public policies focusing on the built environment found outside the health sector but will have significant impacts on the population's health.

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Appendix 1

Recruitment Poster

Phase III Focus Groups

Recruitment Poster

PARTICIPANTS NEEDED FOR
RESEARCH ON THE AIR QUALITY HEALTH INDEX (AQHI)

We are looking for 5 to 8 volunteers who (are parents of young children, seniors 65+ years or have an existing breathing condition (i.e. asthma, COPD)) to take part in an AQHI focus group discussion. The purpose of the discussion is to find out what things may be affecting peoples' use of the Air Quality Health Index (AQHI) so we can figure out how to get people in Hamilton to use the AQHI. Using the AQHI could help people lessen their exposure to pollution in the air.

You would be asked to:

- sit in a **60-75 minute focus group** interview;
- share your thoughts on air quality and health and the Air Quality Health Index (AQHI); and
- provide some demographic/background information like age and education.

Your participation would involve 1 session
which will be about 1 hour.

In appreciation for your time, you will receive AQHI promotional materials (i.e. water bottle, pedometer, beach ball, pen, whistle).

For more information about this study, or to volunteer for this study, please contact:

Sally Radisic
Tel: 905-546-2424 ext. 5549
Email: sally.radisic@hamilton.ca
By _____

This study has been reviewed by, and received ethics clearance by the McMaster Research Ethics Board.

Appendix 2

Recruitment Poster Phase III

Recruitment Poster

PARTICIPANTS NEEDED FOR
RESEARCH ON THE AIR QUALITY HEALTH INDEX (AQHI)

We are looking for volunteers to take part in an AQHI education study for seniors to see if it is helpful in increasing awareness and use of the AQHI.

You would be asked to:

- come to a **30 minute** talk about the Air Quality Health Index (AQHI);
- fill out a 10-15 minute survey on the AQHI before and after the talk; and
- give some background information like age and education.

Your participation would involve 1 session
which will be about 1 hour.

In appreciation for your time, you will receive AQHI promotional materials (i.e. water bottle, pedometer, beach ball, pen, whistle).

For more information about this study, or to volunteer for this study,
please contact:

Sally Radisic
Tel: 905-546-2424 ext. 5549
Email: sally.radisic@hamilton.ca

This study has been reviewed by, and received ethics clearance by the McMaster Research Ethics Board.

Appendix 3

Letter of Information Phase I

LETTER OF INFORMATION
Phase I - Survey

A Study about the Factors Influencing Air Quality Health Index (AQHI) Use In the City of Hamilton

Investigators:

Faculty Supervisor:
Dr. Bruce Newbold
School of Geography and Earth Sciences
McMaster University
Hamilton, Ontario, Canada
(905) 525-9140 ext. 27948
E-mail: newbold@mcmaster.ca

Student Investigator:
Sally Radisic
School of Geography and Earth Sciences
McMaster University
Hamilton, Ontario, Canada
(905) 546-2424 ext. 5549
E-mail: radisis@mcmaster.ca

What am I trying to discover?

I am trying to identify what things may be affecting the use of the Air Quality Health Index (AQHI). I am doing this research for a thesis at McMaster University. I am also a Health Hazard Specialist working at the City of Hamilton Public Health Services.

You are invited to take part in this study on factors influencing the use of the Air Quality Health Index (AQHI). I am hoping to learn what things may be affecting the use of the Air Quality Health Index (AQHI).

What will happen during the study?

If you agree to take part in the study you will be asked to fill in a survey. I will be asking you questions about air quality and the Air Quality Health Index (AQHI). I will also ask you for some demographic/background information like your age and education.

Are there any risks to doing study?

The risks connected with participating in the study are no greater than the risks you come across in everyday life. Please note that the Air Quality Health Index (AQHI) is a relatively new tool so many people will not be aware of it and able to answer questions about it. Please feel free to skip any questions you do not wish to answer in the survey. And you can stop taking part at any time. If you ask, I will be happy to send you a summary of the study results at the end of the research.

Are there any benefits to doing this study?

The study strives to let the local public health agency know about what things affect the use of the Air Quality Health Index (AQHI) so that steps can be put in place to increase the use of the AQHI within the City of Hamilton and people will be able to lessen their exposure to pollutants commonly found in the air.

Reimbursement

For participating in the study you will receive Air Quality Health Index (AQHI) promotional material.

Who will know what I said or did in the study?

No one but the researcher and research assistant(s) will have access to the data you provide. The information/data you provide will be kept in a locked desk/cabinet. Information kept on a computer will be protected by a password. Once the study has been completed, the data will be destroyed.

What if I change my mind about being in the study?

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop, at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. You can withdraw at any time or up until approximately January 2014.

How do I find out what was learned in this study?

I expect to have this study completed by approximately January 2014. A summary of the results will be posted at: www.hamilton.ca/aqhi and McMaster University's website. If you would like to receive the summary personally, please let me know how you would like me to send it to you.

Questions about the Study

If you have questions or require more information about the study itself, please contact me. This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance.

If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Research Office for Administrative Development and Support
E-mail: ethicsoffice@mcmaster.ca

Appendix 4

Letter of Information

Phase II Interviews

LETTER OF INFORMATION
Phase II - Interviews

A Study about the Factors Influencing Air Quality Health Index (AQHI) Use In the City of Hamilton

Investigators:

Faculty Supervisor:
Dr. Bruce Newbold
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Student Investigator:
Sally Radisic
School of Geography and Earth Sciences
McMaster University
Hamilton, Ontario, Canada
(905) 546-2424 ext.5549
E-mail: radisis@mcmaster.ca

What am I trying to discover?

I am trying to identify what things may be affecting the use of the Air Quality Health Index (AQHI). I am doing this research for a thesis at McMaster University. I am also a Health Hazard Specialist working at the City of Hamilton Public Health Services.

You are invited to take part in this study on factors influencing the use of the Air Quality Health Index (AQHI). I am hoping to learn what things may be affecting the use of the Air Quality Health Index (AQHI).

What will happen during the study?

If you agree to take part in the study you will be asked to participate in a 30-45 minute interview. I will be asking you questions about air quality and the Air Quality Health Index (AQHI). I will also ask you for some demographic/background information like your age and education. I will be taking some notes and using an audio-recorder.

Are there any risks to doing study?

The risks connected with participating in the study are no greater than the risks you come across in everyday life. Please note that the Air Quality Health Index (AQHI) is a relatively new tool so

many people will not be aware of it and able to answer questions about it. Please feel free to skip any questions you do not wish to answer in the survey. And you can stop taking part at any time. If you ask, I will be happy to send you a summary of the study results at the end of the research.

Are there any benefits to doing this study?

The study strives to let the local public health agency know about what things affect the use of the Air Quality Health Index (AQHI) so that steps can be put in place to increase the use of the AQHI within the City of Hamilton and people will be able to lessen their exposure to pollutants commonly found in the air.

Reimbursement

For participating in the study you will receive Air Quality Health Index (AQHI) promotional material.

Who will know what I said or did in the study?

No one but the researcher and research assistant(s) will have access to the data you provide. The information/data you provide will be kept in a locked desk/cabinet. Information kept on a computer will be protected by a password. Once the study has been completed, the data will be destroyed.

What if I change my mind about being in the study?

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop, at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. You can withdraw at any time or up until approximately January 2014.

How do I find out what was learned in this study?

I expect to have this study completed by approximately January 2014. A summary of the results will be posted at: www.hamilton.ca/aqhi and McMaster University's website. If you would like to receive the summary personally, please let me know how you would like me to send it to you.

Questions about the Study

If you have questions or require more information about the study itself, please contact me. This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance.

If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Research Office for Administrative Development and Support
E-mail: ethicsoffice@mcmaster.ca

Appendix 5

Letter of Information

Phase III Focus Groups

LETTER OF INFORMATION
Phase III Focus Groups

A Study about the Factors Influencing Air Quality Health Index (AQHI) Use in the City of Hamilton

Investigators:

Faculty Supervisor:
Dr. Bruce Newbold
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Student Investigator:
Sally Radisic
School of Geography and Earth Sciences
McMaster University
Hamilton, Ontario, Canada
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E-mail: radisis@mcmaster.ca

What am I trying to discover?

I am trying to identify what things may be affecting the use of the Air Quality Health Index (AQHI). I am doing this research for a thesis at McMaster University. I am also a Health Hazard Specialist working at the City of Hamilton Public Health Services.

You are invited to take part in this study on factors influencing the use of the Air Quality Health Index (AQHI). I am hoping to learn what things may be affecting the use of the Air Quality Health Index (AQHI).

What will happen during the study?

If you agree to take part in the study you will be asked to participate in a 60-75 minute focus group discussion.

I will be asking you questions about air quality and the Air Quality Health Index (AQHI). I will also ask you for some demographic/background information like your age and education. I and/or my assistant will be taking some notes and using an audio-recorder.

Are there any risks to doing study?

The risks connected with participating in the study are no greater than the risks you come across in everyday life. Although all participants sign an Oath of Confidentiality, anonymity cannot be guaranteed. Please note that the Air Quality Health Index (AQHI) is a relatively new tool so many people will not be aware of it and able to answer questions about it. Please feel free to skip any

questions you do not wish to answer in the survey. And you can stop taking part at any time. If you ask, I will be happy to send you a summary of the study results at the end of the research.

Are there any benefits to doing this study?

The study strives to let the local public health agency know about what things affect the use of the Air Quality Health Index (AQHI) so that steps can be put in place to increase the use of the AQHI within the City of Hamilton and people will be able to lessen their exposure to pollutants commonly found in the air.

Reimbursement

For participating in the study you will receive Air Quality Health Index (AQHI) promotional material.

Who will know what I said or did in the study?

No one but the researcher and research assistant(s) will have access to the data you provide. The information/data you provide will be kept in a locked desk/cabinet. Information kept on a computer will be protected by a password. Once the study has been completed, the data will be destroyed.

What if I change my mind about being in the study?

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop, at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise. You can withdraw at any time or up until approximately January 2014.

How do I find out what was learned in this study?

I expect to have this study completed by approximately January 2014. A summary of the results will be posted at: www.hamilton.ca/aqhi and McMaster University's website. If you would like to receive the summary personally, please let me know how you would like me to send it to you.

Questions about the Study

If you have questions or require more information about the study itself, please contact me. This study has been reviewed by the McMaster University Research Ethics Board and received ethics clearance.

If you have concerns or questions about your rights as a participant or about the way the study is conducted, please contact:

McMaster Research Ethics Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Research Office for Administrative Development and Support
E-mail: ethicsoffice@mcmaster.ca

Appendix 6

Consent Form

CONSENT

- I have read the information presented in the information letter about a study being conducted by Sally Radisic**,** of McMaster University.
- I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.
- I understand that if I agree to participate in this study, I may withdraw from the study at any time or up until approximately December 2014**.**
- I have been given a copy of this form.
- I agree to participate in the study.

Signature: _____

Name of Participant (Printed) _____

1. …Yes, I would like to receive a summary of the study's results.
Please send them to this email address _____
or to this mailing address: _____
_____
_____

… No, I do not want to receive a summary of the study's results.

Appendix 7

Survey Instrument

Phase I

Air Quality Health Index (AQHI) Use Survey

The Air Quality Health Index (AQHI) was rolled out in July of 2011 for Hamilton. Please take a few minutes to assist us in understanding AQHI outreach in Hamilton by completing this survey. Please check best possible answer☐ . You can skip any question you do not wish to answer.

DO NOT PUT YOUR NAME ON THIS SURVEY!

Tell us a little about yourself?

1. What is your postal code? _____

2. Where do you live?
   a. Ancaster☐
   b. Dundas☐
   c. Flamborough☐
   d. Glanbrook☐
   e. Hamilton☐
   f. Stoney Creek☐
   g. Other☐ Please Specify_____

3. What is your age?
   a. 18-24 ☐
   b. 25-34 ☐
   c. 35-44 ☐
   d. 45-54 ☐
   e. 55-64☐
   f. 65-74☐
   g. 75 and over☐

4. What is your sex? Male☐ Female☐

5. What is your household income?
   a. Under 15 000 ☐
   b. 15 000-20 000 ☐
   c. 21 000-30 000 ☐
   d. 31 000-40 000 ☐
   e. 41 000-50 000 ☐
   f. 51 000-60 000☐
   g. 61 000-70 000☐
   h. 71 000-80 000☐
   i. 81 000-90 000☐
   j. 91 000 and over☐

6. What is the highest level of education you completed?

Elementary School ☐ High School☐ Trade☐ College☐ University☐

Your Health

7. Do you have any of the existing respiratory (breathing) conditions?

Yes ☐ No ☐ Not Sure ☐

8. If **YES**, which condition(s)? Check as many as apply.
   a. Asthma ☐
   b. Chronic Obstructive Pulmonary Disease (COPD) ☐
   c. Bronchitis ☐
   d. Emphysema ☐
   e. Other ☐ Please Specify _____

9. Do you have any existing cardiovascular (heart) conditions?

Yes ☐ No ☐ Not Sure ☐

10. If **YES**, which condition(s)? Check as many as apply.
    a. Angina☐
    b. Previous Heart Attack☐
    c. Congestive Heart Failure☐
    d. Arrhythmia ☐
    e. Other ☐ Please Specify _____

11. How would you describe your current overall health?

Very Good☐ Good ☐ Fair ☐ Poor ☐ Very Poor☐

12. Do you think the **air** in your neighbourhood affects your health?

Yes ☐ No ☐ Not Sure ☐

Please tell us **WHY** or **WHY NOT**?

Please Remember to Turn over and Complete both sides of the Survey!

13. How long have you felt this way about the air in your neighbourhood?
    a. Last week ☐
    b. Last month ☐
    c. Last 6 months☐
    d. Last year ☐
    e. Last 5 years☐

f. Last 10 years ☐
g. Other ☐ Please Specify _____

14. Do you think the **physical environment** (i.e. **buildings**, **vehicles/traffic**, **trees**, **etc.**) in your neighbourhood affects your health?

Yes ☐ No ☐ Not Sure ☐

Please tell us **WHY** or **WHY NOT**?

15. How long have you felt this way about the physical environment in your neighbourhood?
a. Last week ☐
b. Last month ☐
c. Last 6 months ☐
d. Last year ☐
e. Last 5 years ☐
f. Last 10 years ☐
g. Other ☐ Please Specify _____

16. How much of your time**,** in the summer, is spent **outside** doing **physical activity**?

Most of my time ☐ Some of my time ☐ Hardly any of my time ☐ None of my time ☐

Air Quality Health Index (AQHI)

The Air Quality Index (AQHI) is a scale from 1 to 10 which helps us understand what effect the local air pollution levels may have on our health. The lower the number, the lower the risk.

17. Have you heard of the **Air Quality Health Index (AQHI)**?

Yes ☐ No ☐ Not Sure ☐

Please Remember to Turn over and Complete both sides of the Survey!

18. Do you know what a **High AQHI (7-10)** means?

Yes ☐ No ☐ Not Sure ☐

If **YES**, please tell us what it means to you.

19. Do you know where to check for daily **Air Quality Health Index (AQHI)**?

Yes ☐ No ☐ Not Sure☐

20. If **YES**, where can you check?_____

21. Do you check the **Air Quality Health Index (AQHI)**?

Yes ☐ No ☐ Not Sure☐

Please tell us **WHY** or **WHY NOT**?

22. If you check the **Air Quality Health Index (AQHI**), **how often** do you check?

Always☐ Usually☐ About Half the time☐ Rarely☐ Never☐

23. Do you follow the **AQHI Health Messages** which **tell** you when to **consider reducing or re-scheduling outdoor physical activity**?

Yes ☐ No ☐ Not Sure☐

Please tell us **WHY** or **WHY NOT**?

Thank you!

Please put your survey in the large box on the table marked

"PUT SURVEY HERE"

Appendix 8

Demographic Information Sheet

Phase III

Phase III – Focus Group Demographic Sheet

Please take a few minutes to assist us in understanding AQHI outreach in Hamilton by providing some of your demographic information. Please check best possible answer☐ .
You can skip any question you do not wish to answer.
Please do not put your name on this survey.

8. What is your postal code? _____

9. Where do you live?
   a. Ancaster☐
   b. Dundas☐
   c. Flamborough☐
   d. Glanbrook☐
   e. Hamilton☐
   f. Stoney Creek☐
   g. Other☐ Please Specify_____

10. What is your age?
    a. 18-24 ☐
    b. 25-34 ☐
    c. 35-44 ☐
    d. 45-54 ☐
    e. 55-64☐
    f. 65-74☐
    g. 75 and over☐

11. What is your sex? Male☐ Female☐

12. What is the highest level of education you completed?

Elementary School ☐High School☐ Trade☐ College☐ University☐

Appendix 9

Interview and Focus Group Questions

Phase II and III

Interview/Focus Group Questions

1. Have you heard of the Air Quality Health Index (AQHI)?

2. Where did you learn about the AQHI?

3. Do you know where to check for daily AQHI?

4. Do you check the AQHI?
   Why or Why Not?

5. How often do you check the AQHI?

6. Do you follow the AQHI Health Messages which tell you when to consider reducing or re-scheduling outdoor physical activity?
   Why or Why Not?

7. What do you think can be done to encourage/promote the use of the AQHI?

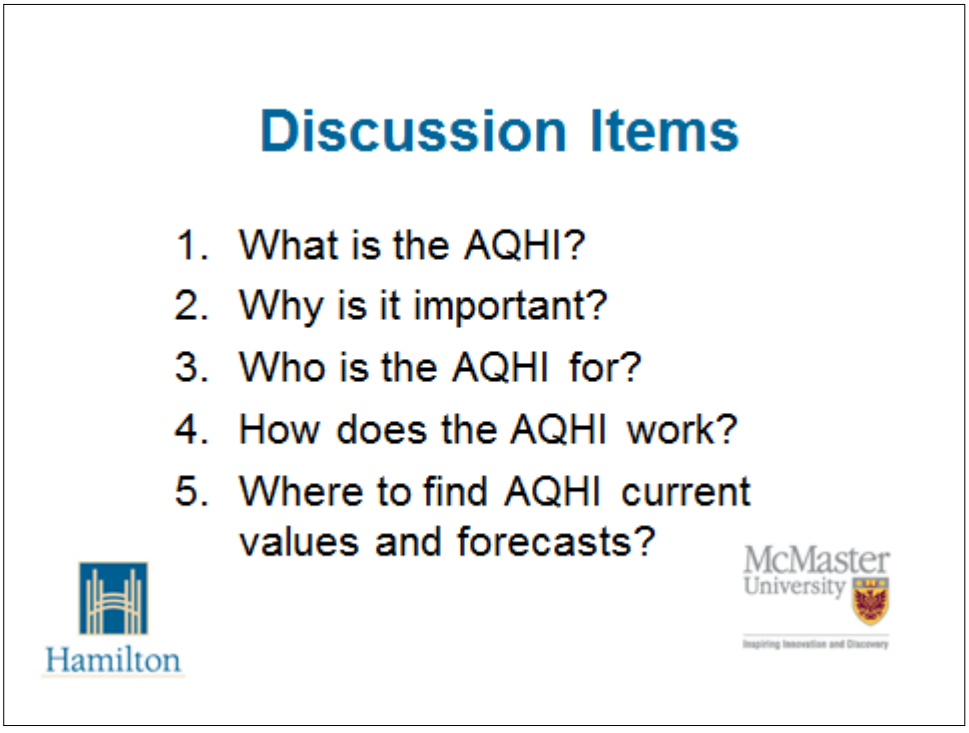
8. Is there anything that I did not cover and you would like to add?

Appendix 10

Senior Education Session Presentation Slide Deck

Phase IV


Air Quality Health Index
(AQHI)
June 19th, 2014
Hamilton
McMaster
University


Discussion Items
1. What is the AQHI?
2. Why is it important?
3. Who is the AQHI for?
4. How does the AQHI work?
5. Where to find AQHI current values and forecasts?
Hamilton
McMaster
University

What is the AQHI?

- AQHI is a scale from 1 to 10
- It is incorporates 3 common air pollutants:
  - Nitrogen Dioxide
  - Ozone
  - Particulate Matter
- These 3 are identified as the best indicators of the effects of air pollution on human health
- AQHI helps us understand what effect the local air pollution levels may have on our health

Hamilton

McMaster University

Inspiring Innovation and Discovery

What is the AQHI?

McMaster University

Inspiring Innovation and Discovery

- The lower the number the lower the risk
- The higher the number the higher the risk
- AQHI current values and forecasts maximums are provided for **today**, **tonight** and **tomorrow**

Hamilton

Why is the AQHI important?

- AQHI is a health protection tool
- AQHI helps you plan a healthy day by limiting short-term exposure to air pollution
- AQHI can help you decide when to enjoy the benefits of outdoor activities and when to **reduce** or **reschedule** you activity

Hamilton

McMaster University

Why is the AQHI important?

- Air Quality is influenced by many different things (i.e. transportation, industrial and residential sources)
- **So how do we know what the air quality is like at any given time?**

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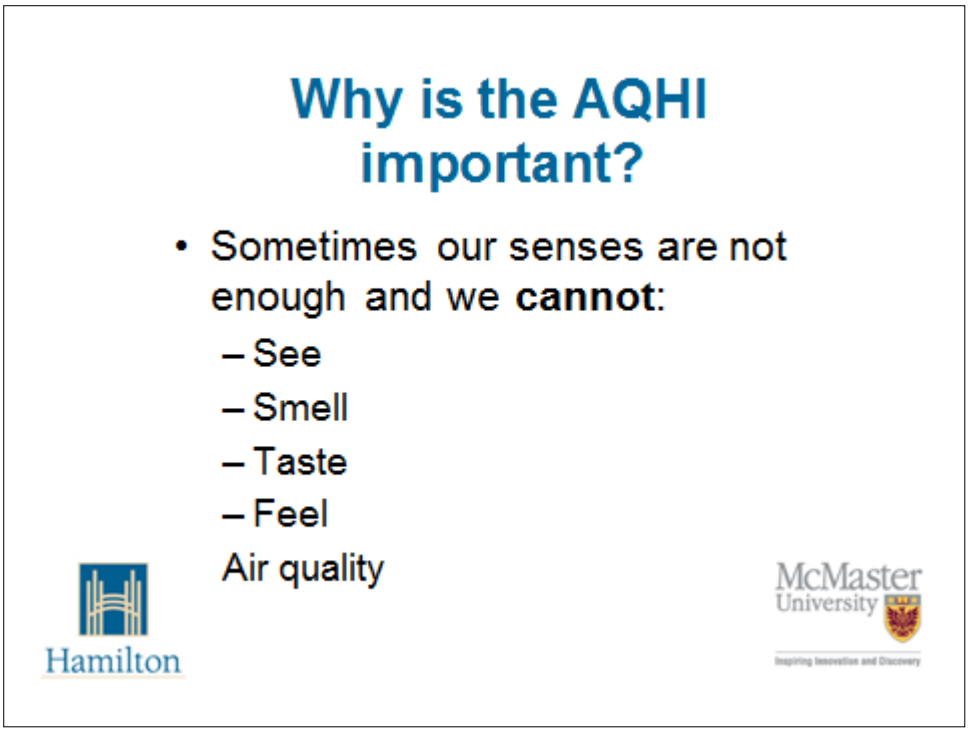
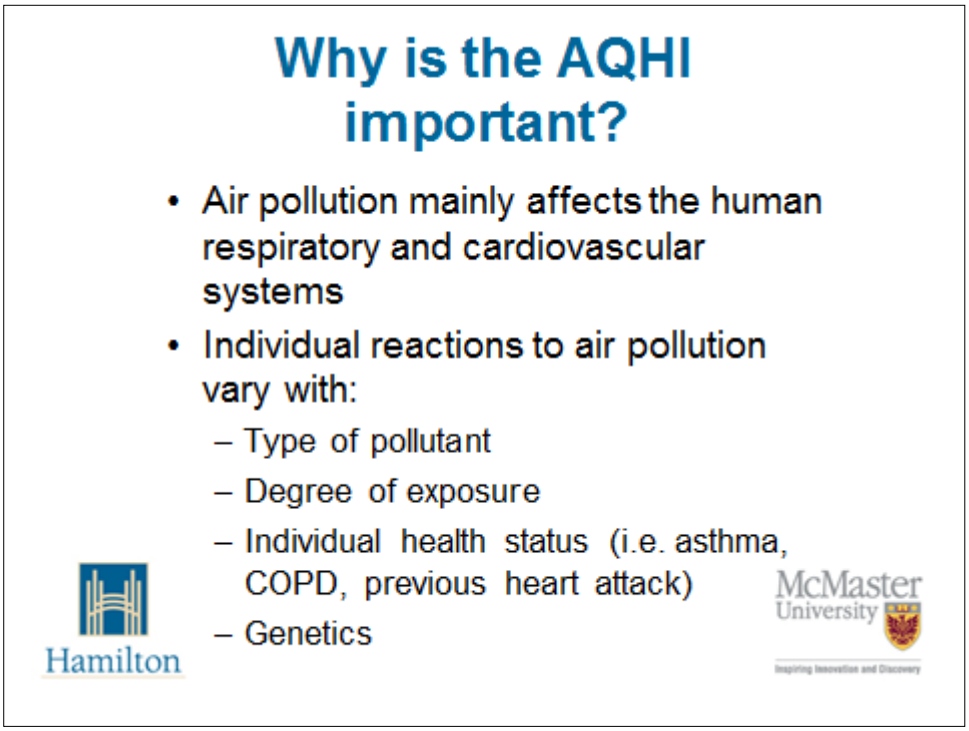
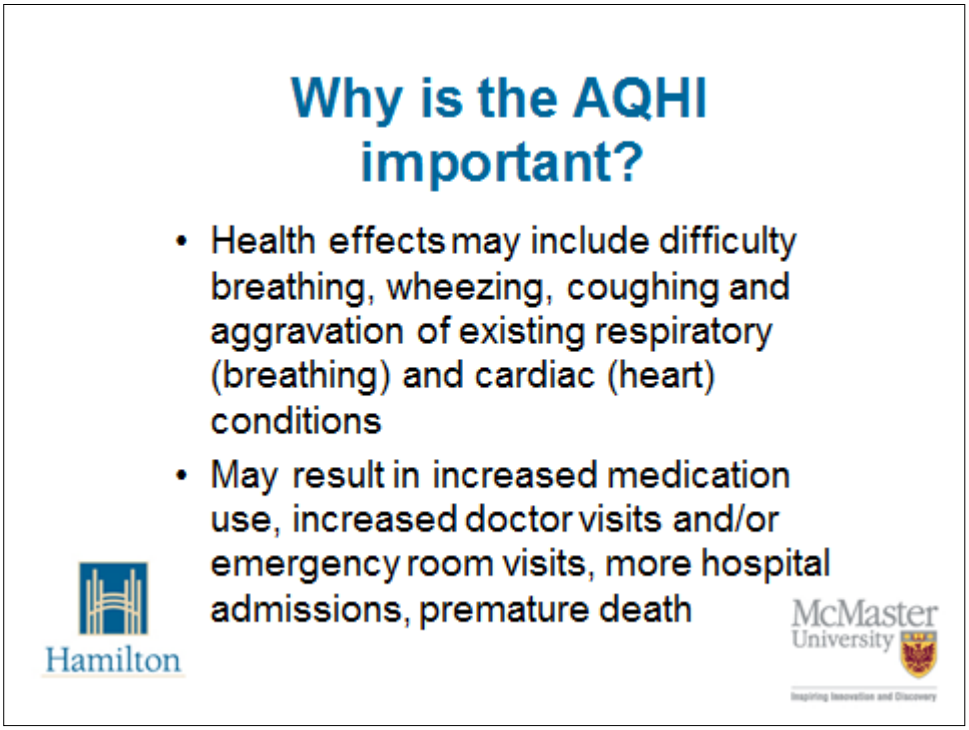
McMaster University


Why is the AQHI important?
• Sometimes our senses are not enough and we **cannot**:
– See
– Smell
– Taste
– Feel
Air quality
Hamilton
McMaster University


Why is the AQHI important?
• Air pollution mainly affects the human respiratory and cardiovascular systems
• Individual reactions to air pollution vary with:
– Type of pollutant
– Degree of exposure
– Individual health status (i.e. asthma, COPD, previous heart attack)
– Genetics
Hamilton
McMaster University


Why is the AQHI important?
• Health effects may include difficulty breathing, wheezing, coughing and aggravation of existing respiratory (breathing) and cardiac (heart) conditions
• May result in increased medication use, increased doctor visits and/or emergency room visits, more hospital admissions, premature death
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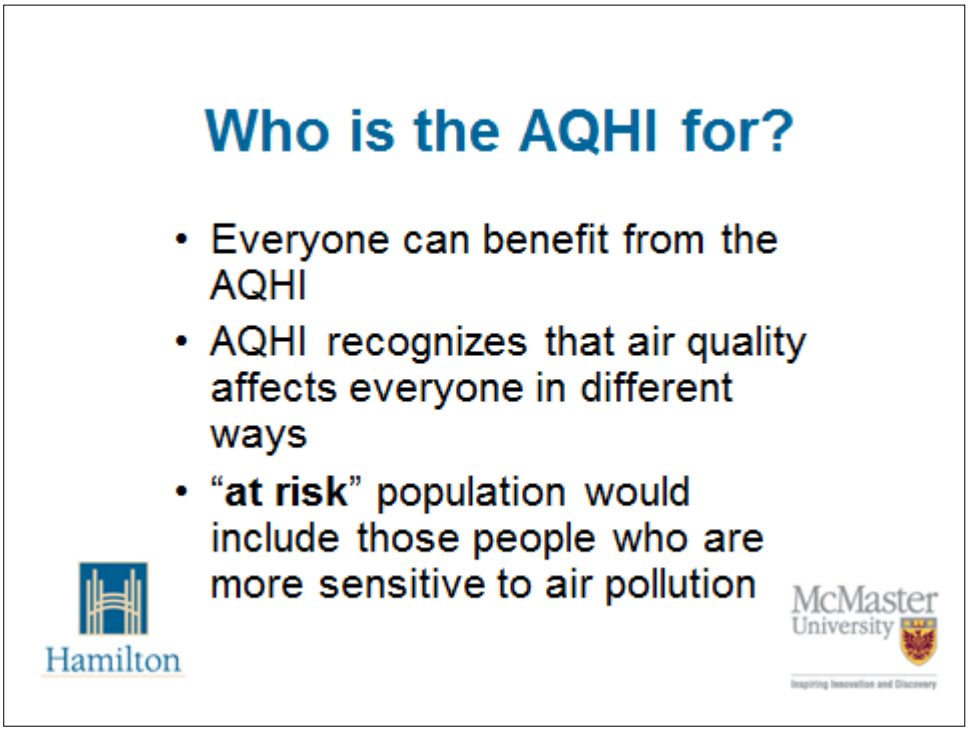
McMaster University


Who is the AQHI for?
• Everyone can benefit from the AQHI
• AQHI recognizes that air quality affects everyone in different ways
• "at risk" population would include those people who are more sensitive to air pollution
Hamilton
McMaster University

Who is the "at risk" population?

- Young children
- Elderly
- People with pre-existing respiratory (breathing) conditions (i.e. asthma, COPD)
- People with pre-existing cardiovascular (heart) conditions (i.e. angina, previous heart attack)

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McMaster University

How does the AQHI work?

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	General Population
Low	1 - 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate	4 - 6	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7 - 10	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

Source: Environment Canada

Hamilton

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Where to find daily AQHI values and forecasts ?

- Weather network
- Environment Canada's telephone weather service line at 905-543-1136
- AQHI website www.hamilton.ca/aqhi
  www.airhealth.ca

Hamilton

McMaster University

City of Hamilton Map

Hamilton

McMaster University

Appendix 11

Senior Education Session Pre/Post Test

Phase IV

Air Quality Health Index (AQHI)
Pre/Post Test Survey

- AQHI was introduced in Hamilton July of 2011.
- Please take a few minutes to help us understand AQHI outreach by completing this survey.
- The survey is anonymous.
- The first three questions are for anonymous coding.
- Please check best possible answer ☐.
- You can skip any question you do not wish to answer.

1) What are the first three letters of your Mother's first name?
___ ___ ___

2) What are the first three letters of the Month you were born? ___ ___ ___

3) What are the first three letters of the Street on which you live? ___ ___ ___

4) What are the first 3 digits of your postal code? ___ ___ ___

5) Where do you live?
a. Ancaster☐ e. Hamilton☐
b. Dundas☐ f. Stoney Creek☐
c. Flamborough☐ g. Other☐ Please Specify_____
d. Glanbrook☐

6) What is your age?
a. 55-64☐
b. 65-74☐
c. 75 and over ☐
d. other ☐

7) What is your sex? Male☐ Female☐

8) The Air Quality Health Index (AQHI) measures **air quality** in relation to **health** on a scale from 1 to 10.

True ☐ False☐

9) Which of the following is used to calculate the Air Quality Health Index (AQHI)? (Check as many as apply.)

a. Nitrogen Dioxide☐ e. Pollen ☐

b. Ozone ☐
c. Particulate Matter ☐
d. Odour ☐
f. Humidity ☐
g. Heat ☐

10) An Air Quality Health Index (AQHI) reading of 7 means that the **risk** of developing health symptoms is **higher** than usual.

True ☐ False ☐

11) Which of the following statements about Air Quality Health Index (AQHI) Health Messages are true (Check all that apply):

a. advise how you can protect your health from the negative effects of air pollution ☐
b. different for the "at risk" population and the general population ☐
c. are available for different levels of health risk (i.e. Low Risk, Moderate Risk, High Risk, and Very High Risk) ☐
d. advise you to avoid sun exposure ☐

12) The Air Quality Health Index (AQHI) helps you plan your outdoor activity by showing the current value and the maximum forecast for:
(Check all that apply.)

a. today ☐
b. tonight ☐
c. tomorrow ☐

13) The Air Quality Health Index (AQHI) is a tool that helps you plan and decide when to:
(Check all that apply.)

a. be active outdoors ☐
b. reduce your outdoor activity ☐
c. reschedule your outdoor activity ☐
d. apply sunscreen ☐

14) Where could you check for the Air Quality Health Index (AQHI)?
(Check all that apply.)

a. Television Weather Network ☐
b. Website ☐
c. Environment Canada Air Quality Health Index (AQHI) Telephone Number ☐
d. Other ☐ Please Specify _____

15) People who may be more sensitive to air pollution include:

(Check all that apply.)

a. Young children ☐
b. Elderly ☐
c. People with pre-existing respiratory (breathing) conditions ☐
d. People with pre-existing cardiovascular (heart) conditions ☐

16) Are you part of any of the "at risk" populations noted above?

Yes ☐ No ☐ Not Sure ☐

17) If Yes, please indicate which of the "at risk" populations:_____

18) The Air Quality Health Index (AQHI) communicates Health Messages **ONLY** for the "at risk" population.

True ☐ False ☐

19) Do you currently **use** the Air Quality Health Index (AQHI)?

Yes ☐ No ☐ Not Sure ☐

Tell us **Why?**

20) Do you **plan/intend** to **use** the Air Quality Health Index (AQHI)?

Yes ☐ No ☐ Not Sure ☐

Tell us **Why?**

21) What information, programs or services would help you use the Air Quality Health Index (AQHI)?

Thank You

Your feedback is important to us.